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# NATIONAL IRRIGATION,

*Ec. Ec.*



*From the author*  
**NATIONAL IRRIGATION,**

OR THE

*To H. Chap*  
VARIOUS METHODS OF

**WATERING MEADOWS;**

AFFORDING

MEANS TO INCREASE THE POPULATION,  
WEALTH, AND REVENUE OF THE  
KINGDOM,

BY AN

AGRICULTURAL, COMMERCIAL, AND GENERAL

ECONOMY IN THE USE OF WATER.

---

By **WILLIAM TATHAM,**

AUTHOR OF THE POLITICAL ECONOMY OF INLAND NAVI-  
GATION, AN HISTORICAL ESSAY ON THE CULTURE AND  
COMMERCE OF TOBACCO, COMMUNICATIONS CON-  
CERNING THE AGRICULTURE AND COMMERCE  
OF AMERICA, &c.

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# DEDICATION.

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TO SIR JOHN SINCLAIR,

BARONET OF ULSTER, &c. FIRST AND  
LATE PRESIDENT OF THE BOARD  
OF AGRICULTURE, &c. &c.

12-13-37 71172-  
SIR,

THE pressures of a war, to the merits whereof I am unfortunately blind on all sides, have compelled me to capitulate with custom, which imposes the condition of a dedication; and to this you politely assent, because I am persuaded that it may gratify many when they are apprised that you

b have

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have seen and approved the essential parts of my book.

I trust posterity will consider this concession, from both of us, an *honorable surrender*: they will at least learn, that we have devoted our thoughts to pacific improvements in the midst of strife and tumult; and they will perhaps credit that I am neither vain enough to suppose you will derive honor from any dedication of mine, or weak enough to believe you think so.

The true end of this address then will be to advertise society that we mutually agree concerning the substance of the following sheets. It is a solid repast which alone suits the palate of a Briton; and I leave the flummery of adulation to those who think so fashionable a desert  
might



might indulge the appetite of a captious critic.

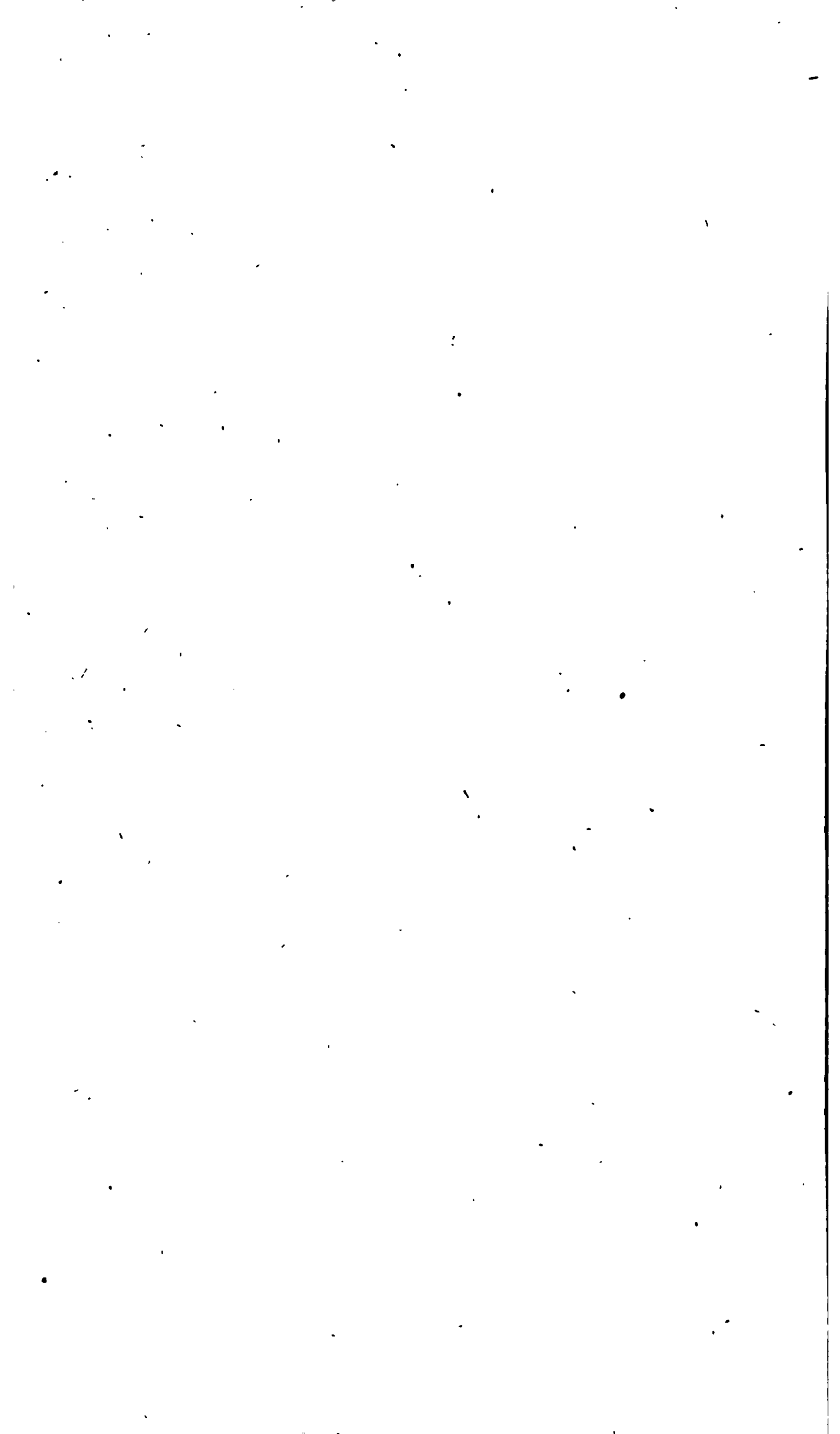
I pray to God to prosper your zeal in the cares of agriculture and humanity, and have the honor to be,

Sir,

Your obedient

Humble Servant,

*WM. TATHAM.*



## INTRODUCTION.

---

**EVERY** man who has been concerned in the publication of a book is apprised, that the printing of the beginning of the work is the last office of the Printer, though it is not always so with the Author.

The writer, however, who has time and experience on his side, may sometimes on this account have a better opportunity of correcting himself in the case of an oversight; of apologizing for those inadvertencies which are wont to beset the studious man; and of apprising his readers more fully of the tendency of his design.

The language in which mine is communicated is a matter of such little importance, so that it be but intelligible, that I shall make no apology for the defects of  
erudition:

erudition: it satisfies me that liberal minds will distinguish the kernel from the shell.

In devising a plan for the nation to profit by, I have thought it proper to review the science which I have ventured to recommend an attention to; and to trace, as far as they have occurred to me, the practical examples whereby individuals may reap instruction and wealth. Zealous to promote these useful ends I have been less solicitous about the eclat of the means I have used; and there will, probably, be found inaccuracies of style and composition which I do not profess to judge of. I perceive also some little degree of oversight in my recitals, which I feel incompetent to correct according to the tide of criticism: I can only say, that I have endeavoured to give Cæsar the things which belong to him, and to render to society all those duties I feel impressed with.

In the course of my readings I have selected specimens of irrigation from various countries; and I have endeavoured to arrange them in a kind of collective order, so that the several methods, the means and the results may afford stimulus and practical instruction

struction from more than the resources of theory. I cannot but lament that the state of the times prohibits the expence of illustrating, in this first essay, all the varieties of machinery which might well apply on plates.

The subject of warping, though somewhat new and local, will be found worthy observation; and I flatter myself that this little book will prove the means of introducing it into many countries where it has never been heard of, and of stimulating the practice of flooding on such rivers as the Mississippi, where the richest particles of the soil have too long been permitted to waste with the unheeded decrease of inundations, naturally favourable to agriculture.

The irrigations of the Nile, of Spain, and of France, afford many examples which deserve the notice of the nation and of the practical farmer; while the English Counties, on the other hand, remunerate lessons to those who have taught them. None of them are without some peculiar point of instruction: Lincolnshire affords examples for low and funken grounds; Gloucester and Wiltshire, a complete system for level meadows in ordinary; Cheshire, a singular method

thod of procraſtinating water on hilly lands ; and Devonſhire combines the watering of meadows with the means of conveying its produce.

I have paid but little attention to the head of objections againſt irrigation, becauſe all which have occurred to me ſeem to be ſo futile as to need no extraordinary arguments to ſurmout them ; and the reſults which are exhibited bear an unanimous teſtimony in their favour.

The irrigation of Aberdeenshire has furniſhed a new diſcovery of no ſmall importance : it has proved to us that heath may be changed into graſs by the mere act of ſimple irrigation ; and it leads to a mode of levelling which deſerves the national care. It does more than this, it introduces us to the knowledge of an author, who, in my opinion, has done more for the cauſe of humanity than the victories of Egypt ; and whoſe whole life and works are replete with benevolence and productive intelligence.

In regard to machinery for the purpoſes of irrigation, it ſhould chiefly be ſuch as the ſmall farmer may command. Simplicity and cheapneſs are the points of advantage which enables him to water more land by a  
few

few feet elevation of his fluid ; and the community will partake the benefit of this medium of accumulated stores. It behoves the public, however, to seek more powerful means to support a general system ; and it should be remembered that public penuriousness ends frequently in private fleecing. It is otherwise with the individual for whose use I have recited machines and methods.

The inclosure of waste lands, and the culture of timber, appear to me to be among the first considerations of British improvement ; and I submit to the reader the manner in which I have connected them with the science of irrigation. I have endeavoured to give an ample example of the capacity of canals in my plan for extending them through the mountains of my native country ; and I have only to lament that I can neither attach the power of my ancestors to my inclination to improve them, or perhaps rouse my relations, who possess many of them, to see the amelioration which they are capable of receiving. If, however, a more thinking part of society should see the state of things with my eyes, and should prove the solidity of my theory by practice ; there will remain no difficulty as to the residue

fidue of the kingdom : for every body must be satisfied, that a system which subdues the most stubborn heaths and hills, will be competent to extend itself into every part of the island.

On the subject of artificial springs I could never enforce too much ; but it will possibly be more efficient if I leave the reader to his own reflection, and an inspection of the apparatus.

In the subsequent part of my book, I trust the statesman will find himself still more interested : it cannot be a matter of indifference to him that there is a great extent of territory which may be irrigated ; that the landed income is capable of increase ; that the value of irrigation can be ascertained by experience ; that the nation possesses both resources and ways and means ; or that my plan for national improvement can be employed to increase the revenue by enriching the individual.

So far as the people of this great metropolis are concerned, I presume it interests them to conquer villainy and fire ; and on these points I refer them to my plan for the management of criminals, and the example  
for



for watering houses, which I have applied to Bedford Square.

Ultimately, I request a notice of my hints towards laying the dust of roads ; this subject merits, and has capacity for, more investigation than I have time to give it : and, though it is certainly a luxury worth regarding that we can travel without raising the dust, it is still more important to the health and strength of the noble animal who conveys us, and more so to the pocket which must pay for the too thoughtless destruction of him.

It remains as a consolation, let what may be the fate of my book, that the Board of Agriculture seem to correspond with me in opinion of the subject, as their circular letter will attest.

In submitting my writings to the public perusal, I have only to wish that they may reap from them as unlimited profit, as tracing these subjects has given satisfaction to

January 18,  
1801,

*THE AUTHOR.*

CON-



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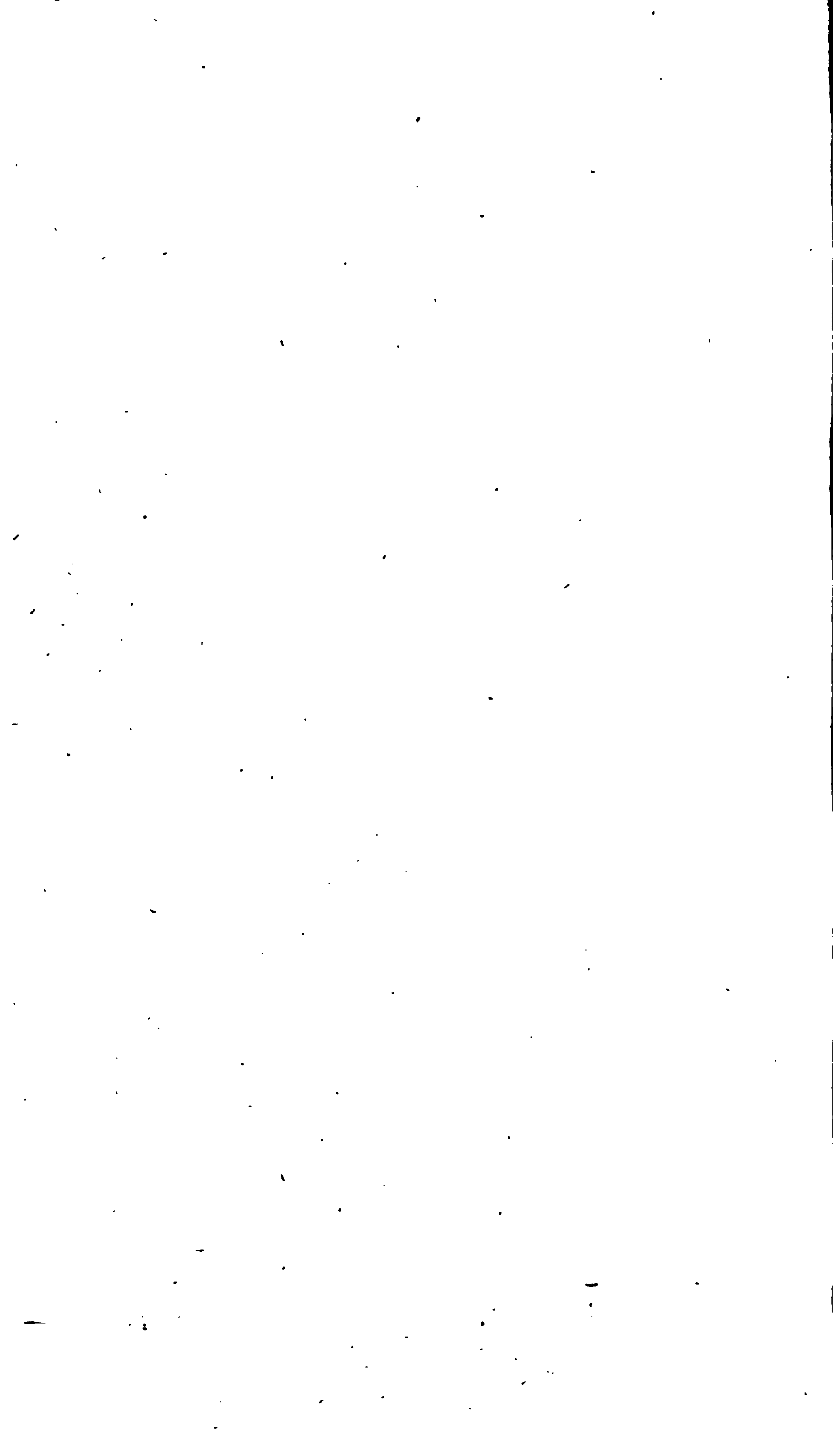
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MEANS



# MEANS

TO INCREASE THE POPULATION, WEALTH, AND  
REVENUE OF THE KINGDOM, BY VARIOUS METHODS  
OF WATERING MEADOWS; AND BY AN AGRICULTURAL, COMMERCIAL, AND GENERAL  
ECONOMY IN THE USE OF WATER.

---

## PRELIMINARY REMARKS.

**T**HERE are three leading principles particularly appropriate to the Kingdom of England, which generate confidence abroad, and afford apparent security to its territorial possessions at home, under the distinctions of *meum* and *tuum*:—these are, the stability of its legal maxims; the strict integrity of its commercial engagements; and its long-tried inaccessibility to a foreign enemy.

Such a basis as this may enable government to obtain a credit, both at home and abroad, upon all its rational anticipations of *future* eligible profit upon *present* undertakings of internal improvements, that are founded upon sound data.

B

Recurrence

Recurrence to past events will afford an easy-discovered example, in numerous instances, of royal bounties, containing immense capacities, from whence public agents find it difficult to gather aid in the time of need, through the unpopular medium of *taxation*: yet possibly in many instances the individual proprietor is found wholly inattentive to a *passive* subject matter, which remains uncultivated in his hands; and thus withholds its proportionate ratio of public resources, for want of an application of the active means of production.

This experience seems to urge the propriety of GOVERNMENT ITSELF UNDERTAKING extensive operations, to render its *own* means productive, in preference to lavishing them upon men of inactive dispositions; because they will find it easier to exercise a will over that which they actually possess, than to support the expence of public operations by reclaiming ever so just and reasonable a remuneration from individuals, in a way which necessarily encounters as great a variety of opinions, dispositions, and self-conceited interests, as it may chance to meet with different faces and complexions.

I perceive a very considerable mistake in  
some



some foreign countries with respect to the true *national circumstances of Great Britain*. The kingdom is believed to be in the highest possible state of culture and manufactures, and overflowing with population. It is a striking proof of this opinion, that even the Americans, who are scions of the same root, have built most of their late popular misfortunes upon the sandy bottom of this glaring error. I call it *a glaring error*, because I do not think it requires any abundant penetration to discover that Great Britain, under all those advantages of climate and population which have been ascribed to her, is by no means a perfectly cultivated country; or even within a thousand years of her zenith in agriculture or manufactures.—A period which, I trust, will be found sufficient for *our* occasions, and for an honourable redemption of the *public debt*.

But probably she may prove in a condition to effect this object in a tenth part of that time, by the *civil* employment of *all* her people even, *partus sequitur ventrem*, in a way which may afford present resources from prospects of production in futuro, that may justify speculations which will re-

turn fortunes to our grandchildren with certainty.

The establishment of a Board of Agriculture has, perhaps, been one of the wisest theoretic measures that a nation ever adopted; and from the prospects of practice, we are not only led to expect the enrichment of the country through the productive stimulus of individual competition, but while men of active and liberal minds continue in office, and cherish rational designs with the means of experiment and execution, we shall obtain indubitable proofs of existing capacities for an actual improvement of the public resources; and a new field is laid open for the encouragement of individuals in works of national enterprise, through a testimony of truths which stare the foes of harmony out of countenance, and offer *sound* materials for a truly politic superstructure.

We learn from the agricultural views of the several counties, which have been wisely collected to a focal point, under patronage of the Board, that in many of them husbandry has been much neglected, lands remain yet in a state of nature, and the hand of art has but availed itself partially of elementary blessings.

But

But of all the instances of agricultural, household, and commercial economy, which call for the attention of philosophical observation and scientific assistance, none appears to be more conspicuous than the neglect of an *economical use of water*.

Indeed, improvements in respect to the various applications of this element, which might be contrived for our better accommodation, seem to be lost sight of, like most other providential bounties, in an imaginary idea of the superabundant infinity of the natural supply; and an habitual indifference beyond the ordinary purposes which have accompanied custom from early periods of untutored nature.

I have often attempted, in vain, to impress men, to whom fortune had been favorable, with certain ideas which I conceived to be interesting to themselves and to mankind; and have frequently been rebuffed on the ground of *my original projects* with questions whether I had been on the spot? or if I had ever seen the like carried into execution heretofore? as if scientific improvement existed without an origin; as if every new place must need a new philosophical principle: or the generous public spirit

# ANTIENT EXAMPLES OF IRRIGATION.

Let us, however, in the first place recur back to the ancients, and explore the regions of early-improved countries; of Greece, of Rome, of Egypt, and of China.

In Beotia it is said that immense works antiquity, not now to be traced, have been constructed to *drain off*, or to prevent the overflowing of the waters of Lake Copais (according to the Abbe Barthelemi); and that these are distributed in various canals over the whole breadth of the mountain.

There seems to be little doubt that these astonishing works were for the purpose of *agricultural irrigation*; for if they had been contrived, as the Abbe conceives, to prevent the overflowing of the Lake, pray why did not that Lake drown the country before these canals were made? How would it have been possible to get at premises so drowned in the mountain to improve them? Or is there any other probable purpose for

\* See Phillips's Navigation, p. 2, cited from Anarcharis.

which

which they could have been constructed, but the interesting pursuit to which I have attributed their design ?

\* Magnificent aqueducts are said to have been constructed at Rome at a vast expence, for supplying that populous city with water. These are reputed to have been variously formed, both in respect to construction and material; some passing under ground, some above ground, some extending a hundred miles, and built of stone, brick, and wood, as occasion served. Nine of these aqueducts are recorded to have distributed their contents through thirteen thousand five hundred and ninety-four pipes, of one inch diameter, perhaps to culinary uses in part, but greatly to irrigating of gardens and other grounds, as the remains of basins and fountains seem to indicate: nor is it probable, in so high a state of splendor as Rome enjoyed, that these advantages could have escaped their notice.

† The works constructed by the antient sovereigns of Egypt for distributing the waters of the Nile, says Adam Smith, were famous in antiquity; and the ruined remains

\* See Phillips's Navigation, p. 3.

† Smith's W. of Nations, Vol. III. p. 33.

of some of them are still the admiration of travellers. Those of the same kind which were constructed by the antient sovereigns of Hindostan, for the proper distribution of the waters of the Ganges, as well as of many other rivers, though they have been less celebrated, seem to have been equally great. Both countries accordingly, though subject occasionally to dearth, have been famous for their great fertility: though both were extremely populous, yet, in years of *moderate* plenty, they were both able to export great quantities of grain to their neighbours.

Egypt seems to have profited more than any country, not even excepting China, by the fertilizing advantages of irrigation which the overflowings of the Nile afforded, and which were converted to the greatest profit by the care of its antient governments.

The beauty of the canal of *Faoua*, as described, from *Abulfeda*, by Phillips\*, is peculiarly descriptive of the benefits of irrigation: “No prospect can be more enchanting or agreeable. Gardens, groves, and eternal verdure adorn its banks, which are shaded by date trees, covered with vines, and em-

\* Phil. Naviga. p. 5.

bellished with pleasure houses." This canal is said to have been cut from the Nile to Alexandria by Ptolemy, to fill the immense cisterns, which are vaulted with great art, and constructed in all parts of that city. The numerous magnificent aqueducts\* are still almost entire, although they are above two thousand years old; but they are now useless, as they have been for many ages.

Mr. Phillips gives the following account of the irrigations performed by the inundations of the Nile, on the authority of the Baron de Tot: "The annual inundation of the Nile is the source of fertility to Egypt. When the waters have risen to a certain height, the *khalig*, or grand canal, is opened, by which it is conveyed, by a prodigious number of smaller canals, into reservoirs and cisterns, to be distributed among the fields and gardens as it is wanted. To determine when it has attained to this height, a pillar, called a *Nilometer*, is erected in an island opposite Cairo, and divided into *pics*, a measure of about two feet. According to Baron de Tot, the progress of the inundation is observed at the nilometer, situated at the southern point of the island of Rhoda, op-

\* Vide Phillips.

posite Old Cairo. Public criers, distributed in each quarter of the capital, every day make known to the people the rising of the waters, till they are come to the height proper for opening the canal ; by which means they are conveyed to the middle of the city and the cisterns : but this moment cannot be ascertained with precision, because superstition prevents the eye of curiosity from approaching the graduated column placed in the centre of the basin of the nilometer. The cry of “ *Oof-Allah*,” which signifies God has kept his promise, proclaims the opening of the canal. Children, bearing streamers of different colours, accompany the crier, and diffuse a general joy at the certainty of plenty.”

It does not appear that the waters at other times suffice for the agricultural demand of the country ; or that this is the mark of the *greatest* plenty. To produce that degree, the waters must reach the foot of the mountains, and then the criers proclaim, “ *Minel Dgebel il Dgebel*,” from one mountain to another \*.

It appears farther, that there are many

\* Phil. Naviga. p. 6, &c.



other canals, which are merely under the care of those who are particularly interested in their irrigations; and that the culture may be compared to a well-managed kitchen garden.

The lake of *Moeris* was considered as one of the most wonderful labours of the kings of Egypt; and certainly it was not more wonderful than useful.

Different authors, as Herodotus, Diodorus Siculus, Strabo, Pompilius Mela, and Pliny, are somewhat various in their accounts of its size; but all agree in the immensity of its capacity and utility, which are the chief points we should contemplate in the example, and which should stimulate our exertion, with a blush to be so far behind ruder ages whom we occasionally affect to pity.

King Moeris is said to have constructed this grand reservoir by art, with a view to regulate the irrigations of the Nile, as its inundations created a necessity. Two pyramids, each three hundred feet high, were erected in the middle of it, upon a proportionate base\*. Doubtless this is an ample

\* See Rollin's Ancient History, Vol. I. p. 177, Glasgow Edition, 1795.

proof of its being human workmanship ; although the most creditable account makes it no less than seven<sup>o</sup> or eight French leagues in circumference.

From this lake there is a canal of eighty five stadia, or four French leagues long, which communicates with the Nile by proper floodgates or sluices ; and the charge of superintending these was estimated at fifty talents, or fifty thousand French crowns, valued at eleven thousand two hundred and fifty pounds sterling\*. Its fisheries are reputed to have afforded an immense revenue ; but there remains not a shadow of doubt, with me, that its powers of irrigation were both the leading motive to its construction, and the superior sources of wealth with which it abounded : when the Nileometer, for instance, indicated an overflow or dangerous inundation, the opening of the sluices must have contributed to relieve its pressure on its embankments ; and, if a dearth ensued, it is equally certain that so large a body of water must have been important to vegetation.

Without entering into the various philosophical reasonings of the several authors

\* See Rollin's Ancient History, Vol. I. p. 178.

whom

whom I have cited, concerning the rise and fall of the Nile, it will be deemed enough for those who know the river Mississippi, and can compare the two together, to ascertain the actual state of its annual inundations. Although travellers differ indeed in some degree with respect to the period of its rise and fall, it seems tolerably certain that the rains fall in April in Abyssinia, and that the Nile rises slowly about the month of May: this corresponds pretty much with those spring floods of the Mississippi, which may be chiefly ascribed to the dissolution of the mountain snows.

The foregoing account of the nilometer, from the Baron de Tot, gives the quantum of inundation by a measure marked in pica of two feet each, on the column which is erected in the basin of the nilometer, and which probably corresponds with the pyramids in *Lake Moeris*, which may have been erected there for a similar purpose. The Baron has not favoured us with an accurate admeasurement of the floods, on account (he says) of the interfering superstition; but we are enabled to draw a greater degree of certainty from some other historians. Pliny states the just or best medium height  
of

of the Nile at sixteen cubits flood; each cubit being eighteen inches\*. Twelve or thirteen cubits only are said by this author to threaten a famine; and if the rise exceeds sixteen cubits, the fresh becomes dangerous. From hence we may learn the just proportions of the embankments which are demolished, in that country of uniform level which constituted the premises of operation under the kings of Lower Egypt; and, if we may be permitted to leave oracles and superstition at a proper distance behind our senses, we may readily conceive a principle of civil engineering, which is competent to dethrone the river-god of Egypt.

Most of these writers agree in one point somewhat essential to be understood; that is, that the rise and fall of the Nile occupies a quarter of the year, in Egypt; but that this loss of time is made amends for by its fecundating particles and the influence of the sun. Yet, although the husbandman of Memphis seems to have been released by native fertility from any extreme labour of the plough, we find him vigilant in the duties of irrigation which were enjoined by the national

\* Rollin, Vol. I. p. 182.

law, and indicated every where by public indexes or water gages : nor were those who had to water more elevated spots than the common surface unmindful of mechanical means, tho' very far short of the perfection of English mechanics. Spiral pumps, ascribed to the inventive faculties of Archimedes, were applied to purposes of irrigation, both by hand and moved by oxen ; and the sacred record, which has been quoted by Mr. Rollin\*, seems to imply the use of *foot* machines, similar to those described by Sir George Staunton in his travels in China.

We have here, however, a precedent for the public intervention in works of national irrigation ; and are not less without satisfactory proofs of the economical advantages which are made to flow from the paternal care of those thinking monarchs, who have the peace and happiness of their people at heart. It is said, that no country on earth possesses a more fruitful soil than that of the Nile ; yet it is equally ascribed to its system of irrigation. Numberless canals were cut in all directions, to facilitate the overflowing of the lands. The numerous villages which

\* Deuteronomy, xi. 10, 13.

stood on the banks of the river, had each their canals, which were systematically opened to let the water into their country. Villages farther at a distance had similar conduits, in succession, to the extreme of the kingdom; and the waters were conveyed, progressively, to places the most remote.

Persons were not permitted to cut trenches to receive the waters till the river was at such a height; nor to open their trenches altogether. They began with opening them in Upper, and afterwards in Lower Egypt, according to rules that were prescribed in a roll or book, in which all the *gages*, or measures were set down. By this method the water was distributed with such care and economy that it spread itself over the whole surface of the country; and it has been said, of the rains which fall in the upper country, not a tenth part reaches the sea.

It is said, that at two seasons of the year Egypt exhibits a prospect, which is yet unrivalled on the face of the earth\*; how far the Mississippi may in future vie with it, is a point yet undetermined. If a man ascends a mountain, or one of the Pyramids, in

\* See Rollin, Vol. I; p. 187. Seneca Nat. Quest. L. iv.

July or August, he beholds a vast sea, in which numberless towns and villages appear, with several causeways leading from place to place; the whole interspersed with groves and fruit-trees, whose tops are only visible; and the scope is bounded by mountains and woods at the most distant view which the eye can discover.

On the contrary, in the months of January and February, when winter elsewhere prevails, the whole space is a vast expanse of beautiful meadows, bespangled with flowers, and enlivened by flocks and kine, and by numerous herdsmen and gardeners.

Is it not worthy of such a country, that the peasant should hold an honourable name; and that those servile occupations of the herdsman and farmer, which alone afford the means of dissipation to higher ranks, should have an honest pretension to the public esteem?

“It will be always so with every kingdom, says Mr. Rollin\*, whose governors direct all their actions to the public welfare. The culture of lands, and the breeding of cattle, will be an inexhaustible fund of

\* Rollin's Ancient History, Vol. I. p. 220.

wealth in all countries, where, as in Egypt, these profitable callings are supported and encouraged by *maxims of state policy*. And we may consider it as a misfortune that they are at present fallen into so general a disesteem; though it is from them that the most elevated ranks, as we esteem them, are furnished, not only with the necessaries, but even the delights of life."

Again, says the *Abbe Fleury*, in his work on the manners of the Israelites\*, "It is the peasant who feeds the citizen, the magistrate, the *gentleman*†, the ecclesiastic: and whatever artifice and craft may be used to convert money into commodities, and these back again into money; yet all must ultimately be owned to be received from the products of the earth, and the animals which it sustains and nourishes. Nevertheless, when we compare men's different stations of life together, we give the lowest place to the husbandman: and, with many people, a wealthy citizen, enervated with sloth, useless to the public, and void of all merit, has the preference; merely because he has more

\* Cited by Mr. Rollin, Vol. I. p. 220, 221.

† See Doctor Franklin's Tale of the Negro's Hog!

money,



money, and lives a more easy and delightful life."

"But let us imagine to ourselves a country where so great a difference is not made between the several conditions; where the life of a nobleman is not made to consist in idleness and doing nothing, but in a careful preservation of his liberty, that is, in a due subjection to the laws and the constitution; by a man's subsisting upon his estate without any dependance, and being contented to enjoy a little with liberty, rather than a great deal at the price of mean and base compliances—A country, where sloth, effeminacy, and ignorance of things necessary for life, are held in their just contempt, and where pleasure is less valued than health and bodily strength—In such a country it will be much more for a man's reputation to plough, and keep flocks, than to waste all his hours in sauntering from place to place, in gaming, and expensive diversions."

\* La Compte says, that although China was not of itself a fruitful country, its canals would make it so. "One large canal," says he, "generally runs through every

\* See Philips's Naviga. p. 11.

province ; and a vast number of smaller ones are cut from that large one ; which, again, are subdivided into still smaller ones, or rather rivulets, that end at some village or great town. Sometimes they discharge themselves into a lake, or large pond, from whence all the adjacent country is watered ; so that these clear and plentiful streams, embellished by a great number of fine bridges, bounded by great and convenient banks, equally distributed through vast plains, covered with a numberless multitude of boats and barges, and crowned (if I may use the expression) with a prodigious number of towns and cities, whose ditches they fill, and whose streets they form, at once render that country the most fruitful and most beautiful in the world.”

“ \* The Chinese not only make canals for the convenience of travellers, but they also dig many others to catch the rain water which comes down from the mountains, and with which they water the fields in time of drought—more especially in the northern provinces. During the whole of

\* See Sir G. Staunton's Embassy, Vol. II. p. 473, 482, 499, 517, &c.

summer you may see the country people busied in raising this water into abundance of small ditches or channels, which they cut across the fields. In other places they contrive great reservoirs of turf, the bottom of which is raised above the level of the ground about it, to serve them in cases of necessity: besides, they have every where in the provinces of Xensi and Xansi, for want of rain, certain pits, from twenty to a hundred feet deep, from which they draw water with incredible labour. If by chance they meet with a spring of water, it is worth observing how carefully they husband it: they sustain it by banks in the highest places; they turn it here and there a hundred different ways, that all the country may reap the benefit of it; they divide it, by drawing it by degrees as every one hath occasion for it; *in so much, that a small rivulet, well managed, sometimes dispenses fertility to a whole province\*.*"

It is needless to dwell longer on examples of ancient irrigations, or their infinite productions. The memoirs of Major Rennel, the works of Duhalde, Lé Comte, Sir George

\* Philips's Naviga. p. 14.

Staunton, and others, give numerous examples on the Ganges, Burrampooter, &c. ; and many instances of importance are recited in my first volume of the Political Economy of Inland Navigation, Irrigation, and Drainage, &c.

#### IRRIGATIONS IN SPAIN.

In many parts of Europe there are instances of agricultural irrigation, highly worthy of British imitation.

In Spain, where some are wont to suppose men live in wretched indolence and poverty, because they differ from themselves in habits, we find examples of *industrious economy in the use of water*.

Many towns exhibit noble specimens of ornament and use in this respect ; and some have even venerable remains of yet perfect Roman aqueducts, aided by Moorish and modern repairs.

*Almeida's*, or public walks, planted with poplars, are to be found in most of the larger towns, and few of these are without fountains of pleasure and of use ; although  
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## **The Noria of Spain .**

many of them are supplied by the application of animal labour to fill the reservoirs, from whence ducts are distributed abroad to supply the calls of animal thirst, and the absorptions of irrigation.

Reservoirs for irrigation are generally contrived, in Spain, upon what is termed the *Noria* plan.

The *Noria* consists of a mound of earth, raised above the surface of the ground to a convenient degree of elevation, for conducting channels to the various parts of the ground which is intended to be irrigated.

This mound is walled round with brick or stone to keep it compact, or with earth and straw rammed into a *caisson*, in the Moorish manner, similar to the cheaper method of which the poorer *villages* are constructed: such, for example, as the famous village of Puerta la Piche, where Don Quixote is said to have received some of his honorary distinctions.

Upon this mound a reservoir is elevated, together with a machine, worked by cattle, for the purpose of raising water to the reservoir, from a well which is dug below it in the common way; or, where a convenient

cut

cut can be made to some adjacent river or stream, the water is conducted *through an arch*, opening a communication between the bottom of the *Noria-well* and such convenient supply.

The method by which the water is then lifted is, simply, by an endless strap; composed of two ropes passing over a sprocket wheel at the upper extremity, and hanging loose into the water which is contained in the well below. Between these ropes a succession of earthen jars are tied at proper distances, and are thus emptied at each and every revolution into a trough, which conveys the water into the reservoir.

I think in the plains of La Mancha, near Manzanares, I counted about forty of these *Norias* at once in the cultivated grounds, which appear to be applied wholly to the purposes of irrigation: but as there is a grand canal, partly completed, within a small distance of them, it is to be hoped the time is not far distant when these poor people will have much of this labour saved; and it is but justice to the king of Spain to say, that he seems far from being remiss in a paternal care for his people, or a desire to better



better their condition, so far as considerations of political safety may permit him to do it.

With regard to the mere ornamental improvements which are to be met with in his Catholic majesty's gardens at his several palaces, and at the palaces of the bishops, and convents of the clergy, (who have been ever mindful of good things in their way to Heaven) I shall leave them to the description of a more fanciful pen, and content myself with observing a few particulars which admit of cheap and useful introduction into other countries, where I do not find them in practice, or where I think they may be improved upon to general advantage.

In the King's gardens at the palace of Seville, my attention was suddenly awakened by the sound of a trumpet, which seemed to be low and rudely blown; and which I immediately perceived to be that held in the hand of the figure Fame, which just gave me timely notice to jump upon a bench out of the way of an artificial shower in reverse, that proceeded from under my feet, and performed the three-fold office of irrigating and cleansing the adjoining borders and walks.

The contrivance is thus constructed: an aqueduct, which receives the water from a

canal that collects its supply about six miles off, in the country, and is carried upon arches elevated upon pillars, forming a kind of colonnade, by the side of an old Roman way for about half a mile, from a corn mill to the city, passes close by the palace; and supplies the baths “of the antient Queens,” (*perhaps of the haram*) and the fountains in the gardens, which appear to have been repaired by the Moors, upon a foundation laid by the Romans, as is evidenced by several specimens of antient sculpture, both colossal and characteristic, which were dug out of the gardens, and are still preserved in the palace as his majesty’s property.

From this aqueduct there is a pipe which communicates into the wall of the adjacent fountain, which presents a front at the head of the centre walk of the second garden, that leads through evergreens to orange groves, to a labyrinth, several ornamental temples, &c.

The front of this fountain and some part of one side wall, which is beautifully covered with oranges as a wall fruit, are of a rustic grotesque construction, with the water trickling through the artificial rock in imitation of nature. Upon the summit of this ruined

nated wall stands the figure of Fame; and the chief fountain is so contrived, that when the water suddenly fills its pipes from the aqueduct behind it, the air is forced through the trumpet by hydrostatic pressure, and produces a sound which diminishes gradually as the vacuum is filled.

This sound is, I presume, intended as the signal for playing off the fountains; which is also the signal for his majesty's approach, if he designs to be present on public occasions: and it is highly probable that the original invention kept pace with a period when Kings had little more to do than to laugh at their subjects for getting foused; or hazard their lives as trifles in daily tournaments of pleasure. But I think I have seen Charles IV. partake a wetting with his surrounding subjects for experimental purposes of more honor to his heart.

Among the numerous fountains in his Catholic majesty's gardens at Aranjuez, I noticed one which is constructed upon a similar principle with the above, and which calls my remembrance to its simplicity and utility. The principle of operation is the same with that of every other simple fountain, and depends upon the gravity of the head supply,  
or

or pressure of water: but what appears to me to be of most moment is, the contrivance of its ducts, which have a cheap and easy capacity for irrigation, and may, with very little additional expence, be applied to many other hydraulic purposes.

They consist of leaden pipes passed from the reservoir down each side of a flagged walk, and perforated at proper distances with gimblet holes, which penetrate through the wood they are cased with into the hollow of the pipe. This circumstance, regulated by the angle of elevation, enables a distribution of the water into every part of the walk by the turning of a cock, and might be advantageously used for the purposes of horticulture, agricultural irrigation, or distinct conduits for washing the streets of populous cities, thus preserving their harbours from the risk of silting.

If such pipes were laid along the sides of the city road, leading from Paddington, through Pentonville, &c. I think a couple of turncocks would lay the dust at much less charge than the hire of the carts which are employed in this service, with such opportunities of evasion, that the boys who drive them are suffered to gull the public, and  
laugh

laugh at them for being the dupes of a deceptive routine, wherein they study only to wet the middle of the road, for the sport of dusting those who walk the foot-paths, near the dirty-neglected edges.

In addition to the methods of irrigating in Spain; more or less of which is performed through aid of the fountain ducts in most instances, they seem to be attentive to the accommodation of animal thirst, by the construction of watering places by the way side; and some whereof, (particularly one which I observed in the dividing ridge between the waters of the Duero and Ebro rivers, not far from Breviesca, in the province of Burgos) have conduits, of some miles in length, from a more elevated summit level.

## IRRIGATION IN AMERICA.

I had written most of what I shall notice in respect to irrigation on the other side of the Atlantic ocean, before the second volume of *Communications to the Board of Agriculture*, published this year, 1800, came before the public. It is, therefore, an after view of my manuscript, which discovers to me how widely I have differed from the account of American irrigation, communicated by Mr. Strickland of York, whom I personally know, and personally esteem. I premise this circumstance, and shall also let my work stand as it is, lest I should be conceived to be influenced by a malevolent spirit in the contradictions I feel myself bound to maintain without retraction; both now, in the case of irrigation, and hereafter, in some other instances where a regard to truth and justice renders it my duty to volunteer it against those who may have practiced impositions on Mr. Strickland, either through a want of information, or a desire to gratify a splenetic prejudice, too circum-

circumscribed, I fear, to extend its inquiries with liberal trouble.

I shall make no other apology for this dissentient, than one which *reason* will, I doubt not, admit: *a disinterested person, born in England, and having thirty years personal acquaintance with the premises and people which are spoken of; and one who has been twenty-five years in public life there, and so long acquainted with the extreme frontier of the back parts, will be as likely to know the facts which concern it, as the casual informant of Mr. Strickland's tour.*

It will be observed, however, that Mr. Strickland's personal observations on American irrigation apply chiefly to a part of America which I have not explored; and as the frontiers of the Southern states are, perhaps, not within his journal, it may be of some importance to the present harmonic disposition of the two countries, that, together, we may be able to render the communication more expansive.

\* Mr. Strickland tells us (*as far as he could*

\* *The Agricultural Report of Mr. Strickland's own county, York, claims the originality in that county, within fifty years back.*

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learn)

*learn*) “Irrigation is known only in two parts of the United States, and in neither of them practiced to any considerable extent. It offers no material circumstances worthy of imitation, nor is it conducted on any principles that are not at this time much better understood in this country,” meaning *England*. “*Connecticut* is the most Northern state where it is met with: the practice was probably\* *carried thither* by the first settlers, most of whom emigrated from the counties in the West of England, where it is now best understood; but they do not appear to have kept pace in improvement with their kindred on this side of the Atlantic.

The German tract in Pennsylvania is the other part where it is practised, and the knowledge was carried thither from Flanders or Germany. Two crops of hay are always cut where lands are thus artificially watered.

The law has ordained the right of the water to be in him who possesses the spring head, or the highest part of the stream; he may consume what quantity he pleases, but

\* Communications to the Board of Agriculture, Vol. III. p. 165.



must convey the remainder into the antient channel; he must not divert the stream or waste the water to the prejudice of those below him. The mode of applying the water is different in the two states: in Connecticut it is turned on the land as soon as the weather begins to be warm in the spring; but it is not allowed to flow for more than twenty-four hours at a time: it is then taken off for a few days, then turned on again for twenty-four hours; and so on, till the meadow is nearly fit for cutting: immediately after which, it is applied again in like manner for a second crop, and then again to force the after grafs in autumn; but it is always found to have the greatest effect upon the spring crop.

In this state they also apply water to their lands in another very different unusual manner: they flood great tracts of low meadows, situated on running waters, just before the winter sets in, to the depth of two or three feet, by stopping the course of the stream, and let them thus remain covered till the spring, *in order to keep them warm, and defend them from the frosts.* These lands produce the following year a considerable quantity of coarse hay, which, in conse-

quence of the fine climate in summer, being very well got, is eagerly consumed by the cattle in winter: after the hay is cut, these fields for the remainder of the year are pastures.

In Pensylvania the water is usually turned on the meadows about the middle of April, and is allowed to flow about two months; a few days after which, the ground having got dry, the crop is cut: as soon as the crop is off, the water is again turned on for three or four weeks, or till the land gets a sufficient covering to defend itself from the sun, at that season very powerful: a second crop is then soon ready for the scythe; after which the water is allowed again to flow over it, till within a short time before it is wanted for pasturage, when it is turned off, in order that the ground may so harden, as not to receive injury from the treading of cattle. Which of the two methods of applying the water may be most productive, I know not, not having seen the meadows of Connecticut in the summer season; but those of Pensylvania bear abundant crops.

Water issuing from lime-stone in Pensylvania is thought preferable to any other running stream; but the warm, half-putrid

water

water from a reservoir made for this purpose, which is not unfrequent, or a mill dam, in which it becomes soft, slimy, and muddy, is greatly preferred to all others; water of this kind, at this season of the year, will in Pennsylvania be heated as high as 85° by Fahrenheit's thermometer, and must have a great effect in forcing vegetation.

No art is used beyond a channel, carried on a level, as far as it can be done conveniently, over one side of which it can flow: no means have been taken for raising it above its natural level, which in many places might be performed with much facility.

Since the introduction of clover, these meadows are falling fast into disuse, many of them having been already ploughed up, and converted into tillage: no farther improvements are therefore hereafter to be looked for in this branch of rural economy."

So far Mr. Strickland's account of American Irrigation extends. I shall only here remark, that a longer stay in the country, and a more minute investigation, would have discovered to him, in the Southern and Western states, a few solitary examples, at least, of improvements in irrigation, for which

the people of those countries are no ways indebted to the transplanted genius of South Britain. In South Carolina and Georgia, the rice plantations form an immense irrigation : he might have found watered meadows of tolerable luxuriance in the fork of Broad River and Saluda, commonly called the Dutch Fork. In North Carolina, at the Mornavian towns, at Ramfour's mills, and in many other places, he might have found both common level, and lifted irrigations, performed by cheap and simple wheels ; and in travelling the main road into the Tennessee country, he could not have avoided seeing the very wheel which would accommodate the wishes of the Board of Agriculture : future travellers will find this at Stover town, and many places throughout the back settlements of Virginia ; and the practice of irrigation will be found in the counties of Berkley, Frederick, Shannandoah, Rockbridge, Botetourt, Montgomery, Wythe, Washington, and the Tennessee counties ; reaching from Potomack to the borders of Georgia.

I proceed to the account I had given heretofore without alteration ; and if Gentlemen, who may hereafter seek for irrigation in the Western states of America, will remember to  
look

look for it on Reed creek in Wythe county, or at Captain Craig's, near the town of Abingdon, they will find a lifting wheel worth their imitation, in regard to cheapness and performance.

In the interior parts of America, the Germans and their descendants are particularly attentive to economy in the use of water; and when a Dutchman penetrates into those countries to seek a domain establishment for his family, a good mill seat and a still seat are its two primary recommendations: next to these he estimates the meadow ground; and if nature affords him a water-fall of nine inches perpendicular height, he contrives to elevate it to as many feet, and distributes it round the higher trenches of his meadow, and to culinary purposes, by the help of a simple invention, which he terms his lifting wheel,

A lifting wheel is usually constructed of common deal, oak, or any other boards nailed together in the readiest way which occurs, to approximate such material as you may happen to have, to the shape of a circle, whose diameter is equal to the perpendicular height of the summit level to which you would raise your water at a single operation;

allowing for so much thereof as should dip into the stream to fill your buckets, and so much as should pass above the uppermost trough to discharge the water from them.

This shape is then reduced to an exact circle by the means of a line and chalk extended from its centre, and the surplus plank being hewn down to the scribe of the circle, an axis of about two feet six inches in length is fitted to it with arms of the same plank, and two small iron gudgeons to turn upon. Flutter boards are then fitted on with the saw, and cleated at convenient distances; with a close box between every second and third of them, nailed upon the rim of the wheel. These boxes (by some termed gaining and loosing buckets) have two apertures or holes for receiving and discharging the water; and as the bucket is immersed in the stream below, by the power of this little rapid acting upon the successive flutter boards, the water is taken in at one hole, and discharged out of the other, as the wheel revolves it over the trough above. These are sometimes formed out of a worn-out cart wheel fixed upon an axis, which answers for a small elevation. The nearest description of an invention similar to this wheel, which I have

**Section & Front View of the German lifting Wheel used in America.**

*To face page 40.*





have met with in any of the English authors, is that described by Mr. Ferguson, in page 152 of his Lectures, under the name of the *Persian* wheel. This wheel of Mr. Ferguson's acts in the same manner by a flutter board, and discharges by striking the bucket against a pin at the summit point of its revolution : but the German lifting wheel has greatly the superiority in respect to simplicity and cheapness, which brings it within the reach of every man who occupies land ; and, possessing equal power with the Persian wheel, may be considered steadier in the fixture of its flutter boards, and the best medium between this and the ruder contrivance described by Sir George Staunton, as one applied to similar purposes in China.

## IRRIGATION IN FRANCE.

Mr. Young, in his Three Year's Tour through France, published in 1792, gives a chapter wholly upon the irrigation of that country, from whence many good lights may be derived.

As this work may not happen in the hands of all my readers, I will beg the indulgence of a few extracts from it\*. From Limosin to Limoges, says that popular agriculturist, every spot of land in the mountains is watered that is possible; and with such attention, as marks how sensible they are of the importance of this improvement. The water is conducted very high up the slopes of the hills; and in several instances I was at a loss to conjecture from whence it was brought. But in the low flat bottoms it is badly done, with lines of rushes along the carrier trenches, and little attention paid to the conducting of the water away speedily enough.

\* Young's Tour, p. 363.

Near Gange, we are told in the same work and page, a solid flank of timber and masonry is formed across a considerable river between two rocky mountains, to force the water into a very fine canal, in which it is, on an average, six feet broad by five feet deep, and half a mile long; built, rather than dug, on the side of the mountain, just under the road, and walled in like a shelf—a truly great work, equally well imagined and executed! A wheel raises a portion of the water from this canal thirty feet, by its hollow periphery. An aqueduct, built that height on two tiers of arches, receives the water, and conducts it on arches built on the bridge, across the river, to water the higher grounds; while the canal below carries the larger part of the water to lower fields: an undertaking which must have cost considerable sums.

\* Within a few miles of Gange is another similar irrigation; the water is taken from the river in the same manner, and lifted equally high by another wheel. The whole way through these mountains the exertions in watering are prodigious; there is not an

\* Young's Tour, p. 364.

inch, capable of being irrigated, over which water is not thrown, conducted on the slopes of the mountains every where possible.

\* At Moulins, Monsr. Martin, the gardener of the royal nursery, who is from Languedoc, waters his garden after the manner of that province. A Persian wheel of buckets raises the water from a well twelve feet, the receiver being placed so low as to have five or six of the buckets emptying at a time; and very little water is lost, not the twentieth part, according to all appearance. A horse turns the wheel. It raises two hundred poinçons, each of two hundred bottles an hour. The water is conducted by small channels to all the beds that want it.— I shall have occasion to notice more of Mr. Young's account in another place.

As these, however, are improvements beyond sea, and there may be men who do not choose to trust their monies or belief farther than ocular demonstration upon old English terra firma, I beg leave to call their thoughts to a few examples in daily practice in their own country.

\* Young's Tour, p. 364.

## IRRIGATION IN ABERDEENSHIRE :

*Its Benefit to Agriculture.*

Doctor Anderson, in his report to the Board of Agriculture on the state of husbandry in Aberdeenshire, says, \* there is perhaps no beneficial practice in agriculture which has been so generally neglected in Great Britain as that of watering land. Its fertilizing effects have been sufficiently experienced in our climate to demonstrate, that great benefits might be derived from this application of that useful element; but we are as yet unable to make even an approximated estimate of what the amount of these benefits might be, because we know so little of the variety of cases in which it might be applied, or of the precise nature of its meliorating effects. Perhaps the application that has been made of it in Aberdeenshire goes farther to point out the nature of these future and distant effects, than that of any other part of Britain. It is proved

\* Rural Economy of Aberdeenshire, p. 166.

by the practice there, that if a stream of water is allowed to flow over the surface of a heath-covered moor for a considerable length of time, that moor not only loses the power of producing heath, but it gradually acquires the faculty of producing grass in abundance, as well as corn, and various other crops that, in its natural state, never would have been reared upon it; and that it not only is enabled to produce these crops in consequence of the moisture it furnishes at the time they are growing, but that these effects continue after the water itself is withdrawn; and that of course it operates as a manure, which communicates a permanent fertility to the soil that never can be lost, except by bad management at some future period.

In this point of view it would appear, that every drop of water which is allowed to run into the sea, without having been first spread upon the soil to fertilize it, is a waste of so much valuable manure; and that those who suffer it thus to go to waste, are guilty of nearly a similar crime as those who bury their dung in pits under ground.

They are, however, in the first instance the more excusable, because in many cases the division of property interrupts the progress

gress of water-courses ; and particular servitudes, that have been established in barbarous times, prevent men from availing themselves of a blessing, that otherwise might have been within their reach. If it be true, as Swift asserts, “ that the man who can make two blades of grass grow where only one grew before, deserves more applause than all the warriors and politicians that ever were born ;” it will naturally follow, that those who neglect to do this, when it is within their reach, are equally intitled to blame for misconduct.

Water is peculiarly adapted to the improvement of hilly countries ; because these from their situation admit not of any other kinds of manure being carried to them : for very few hilly countries can be found, where, as in Derbyshire, other manures can be spread upon them.

But, were a large stream of water, such as the Don or the Dee, taken off at a considerable height from the sea, and conducted in a level direction for many miles, it would gradually rise to a great height upon the hills, so as, where the ridges of hills were not discontinued, to rise even to the tops of very high mountains ; all the surface of  
which,

which, below the level of this stream, would gradually be converted into grass instead of heath, were that course continued forward even for many miles. And though the whole of that soil could not be fertilized at once, yet every moment would be adding to the sum total of that fertility ; so as in time to make the whole surface of the most barren heath-ground as fertile as the most luxuriant soils.

And were the owners of such ground, in the course of conducting these canals, to avail themselves of such occasional hollows between the mountains as might present themselves below the level of its course, the outlets from which could admit of being dammed up, so as to be made use of as reservoirs to receive the surplus water in time of floods ; for the purpose of being afterwards distributed by lower channels to such fields as were within their influence—the effect would be much augmented. It is in this way that the natives of India form reservoirs, by them called *tanks*, to be filled with water during the rainy seasons, and afterwards distributed over their rice-fields. Some of these tanks are many miles in length, and in breadth and shape adapted to



to the nature of the ground: nor are these tanks unproductive of even human food; for besides fishes, which are there caught, the thrifty natives plant their bottoms with the *nymphae aquatica*, whose large roots furnish a considerable part of their sustenance; and though we are not as yet in possession of any aquatic plant in this climate which could be employed for that purpose, yet were the fields that are thus occasionally employed as reservoirs, laid sufficiently dry when the waters are off them, they would become very productive of herbage, and much more profitable to the farmer than ever they were in their natural state. I know a hollow that is employed for half the year as a mill-pond, and the other half year as a meadow, which lets at a very considerable rent.

So far Doctor Anderson, who, in speaking again conclusively concerning some of the works for public irrigations in France, on the authority of Mr. Young, who I have herein before cited, farther remarks, that as such public works have hitherto unfortunately been confined to warm countries, men have generally adopted the idea that the only use of such irrigations must be to give

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moisture

moisture to plants when growing, as the great heat of the climate would deprive them of the requisite humidity; and that, of course, in such moist climates as Britain, whose plants are rarely killed with drought, they cannot be wanted. He states the fact as clear, however, and gives the practice of Aberdeenshire as an unexceptionable proof, that water, duly spread over the surface, and judiciously managed, acts always as a permanent manure, that is equally calculated to fertilize the fields and mountains in high latitudes, as to render luxuriant the crops in the vales of torrid regions.

\* Let not Britain, then, says he, boast of her attainments in agriculture, or consider her fields as nearly as productive as they might be rendered, while such immense quantities of water are suffered to flow into the sea, without having ever been employed to fertilize her fields in the smallest degree.

In these positions he perfectly accords with my ideas; nor can I perceive any reasonable excuse that can be offered for a farther delay of the infinite advantages which may be made to flow from so powerful a

\* Rural Econ. of Aberd. p. 170.

source as that of national irrigation. That is certainly not among the least agricultural acquirements which enables us to eradicate a useless heath, and to render it abundantly productive of grass or corn by the simple application of water as a manure: nor can any thing be more laudable than a public attention to these easy means of multiplying the comforts of the community. But we shall explore them to greater advantage in the detail through which we are about to proceed; and I flatter myself that the convictions from thence arising will be productive of many experiments, and of ultimate happy tendency.

## IRRIGATION IN LINCOLNSHIRE.

Sir John Sinclair (fortunately before my work goes to press) has obligingly furnished me with a reference to several instances of advantageous irrigation; both of the kind which we are to consider as simple watering, and that of a more compound nature, termed warping; which, from the circumstance of its forming ultimately the whole soil or su-

perstratum, seems decidedly to merit preference as the most excellent in the catalogue of liquid manures.

It gives me pleasure to find, among the spirited improvements of the thriving county of Lincoln, an example of irrigation under a head where men of investigation alone will, perhaps, look for it: for it seems very inconsistent with vulgar persuasion and prejudice, that one should seek the means of communicating water as an artificial manure, where nature demanded a very laborious operation to drain off a redundancy of moisture\*. Mr. Hoyte, discountenancing hasty decisions on the outward appearance of nature, has been at some pains to analyze the effects of irrigation; while, by discovering, perhaps, the true principles of its beneficial influence, he has succeeded in a combination of watering and drainage which proportions the degrees of moisture, and the fertilizing qualities which accompany them, to the successive calls of vegetation; and applies both to the enrichment of the soil. I shall reserve the subject of warping for its more appropriate place in this work, and, at pre-

\* See Lincolnshire Rep. .p. 239.

sent, take a farther view of the instances I am referred to under the more simple head of watering.

Mr. Hoyte, of Osbornby, of whom we have just had occasion to speak, has given farther specimens of his superior skill and spirit in this kind of improvement, by taking to himself an allotment of poor land, for the laudable purpose of convincing unbelievers in the theory of agriculture, how very far it is possible to practice irrigation with profit. He has availed himself of the undervalued resource of *catch-water drains*, and has irrigated fifty acres at an expence of about fifty pounds\*. This improvement succeeds to his wishes, but it is yet of too recent a date to authorise a decisive account of its product. This Gentleman also has observed and put in practice a leading maxim in irrigation, which seems every where to obtain: he takes care to continue his water (as near as practicable in retaining its nutritious particles) in a constant state of activity, His method is to water three or four days, and then shift. I apprehend, however, that where irrigation is used in a warm season, a

\* See Agricultural Report of Lincolnshire, p. 275.

different practice must be adopted; and, in this respect, a few experiments will be found the best preceptor to govern the variance of soil and climate. Mr. Hoyte uses irrigation in the time of frost for the purpose of destroying sedge; which, in his experiment, is succeeded by the appearance of white clover.

Mr. Young states the produce gained, in this instance, at a ton of hay, and fifteen shillings spring-feed per acre, with nearly the same quantity of after grass. To this we are to add the advantages of early feed for an increasing stock, and the enrichment of the farm by the proportionate accumulation of manure.

In the West Riding of Yorkshire, there are some instances of great advantage derived from irrigating, watering, or floating fields, as it is there termed. Mr. Walker, of Crownest, seems to have studied the easiest mode of commanding his water; and Mr. Ellershaw, of Chappledale, near Ingleton, destroys the moss by floating in the spring season.

## IRRIGATION IN LANCASHIRE.

Mr. W. Vaughan, of Dunster Court, to whose unceasing attentions I am inexpressibly indebted, has favored me with the papers communicated to the Board of Agriculture by Mr. Holt and others from the county of Lancaster: from these I learn that irrigation is yet in its infancy in that county, although there are a few interesting instances which deserve notice, and which I am persuaded, from my personal knowledge of that county, may be repeated with a very happy effect.

\* It is discovered there, by experience, that waters strongly impregnated with metallic or other noxious matter, is improper for the purposes of irrigation in the field of agriculture. Water of any description may nevertheless prove useful to other ends of this science; and in respect to its mechanical application, as a moving power, to machinery, perhaps few counties have received greater benefit than that of Lancaster. Streams of water, which have passed unheeded by

\* Agricultural View of Lancashire, p. 141.

for ages, are said, within a few years past, to have proved of more real value to their present possessors, than the real estates have been worth otherwise to their several proprietors.

How easy would it be for those who have a competent knowledge of hydraulic engineering to convert the numerous little streams of this hilly country to innumerable advantages in agriculture and domestic economy. In this ardent wish, however, if I may be permitted to indulge an anxious hope for its completion, I would be nevertheless understood to apply irrigation to arable lands; and to be always mindful of the culture of corn, let what may be the gain by grazing.

I find a note or two in this authority, which merit particular notice in regard to the lights they afford on the value of water, even in its necessary application to culinary uses. We are told that a freehold in this county has continued for three generations in the possession of a certain family, who (loth, I suppose, to think themselves wiser than their forefathers) have continued in the plain beaten prejudice of carrying a supply upon the head in a pail, from a stagnant pool at a considerable distance. The present possessor,



possessor, it seems, pursued the accustomed track of the family for about fifteen years; but, in the year 1794, took courage enough to commence the tremendous operation of digging a well: this, within six feet of his kitchen door, produced a constant supply of fine spring water, at the very serious expence of seven shillings and sixpence.

A similar waste of labour is frequently to be observed in driving cattle to a distant watering place, when a very small proportion of that labour would bring the water to the farm-yard, and appropriate the saving to a more useful employment in husbandry.

There are two examples near Garstang, in this county, which, from the mention made of them in these papers \*, deserve the attention of those who would profit by a combination of irrigation and drainage. One of these is by W. F. Brockholes, Esq. of Claughton; and the other by Mr. Richard Jones, of Peel, in Little Hulton, near Bolton. But, above all other improvements in irrigation which this county seems to boast, there is one mentioned as an original, which

\* See Lancaster Survey, p. 102.

strikes my mind with an idea of superior importance. *Mr. Bootle's game-keeper, at Latham*, has, by means of ditches, collected water to a pool upon the higher grounds; this pool is constructed with sides of pounded clay, and the water, in its passage to it, past the farm-yard and houses, brings all the fructifying particles with which they are enriched. In this reservoir the water is retained till wanted in dry seasons, or for other partial applications; and, in the principal channels of distribution, he has added marl, through which the water passes, and yields thereby an additional fructification.

I confess I think the reward given to this game-keeper by the Agricultural Society of Manchester has also much merit in it—they presented the good man with a *silver cup*. I hold this very far more estimable, for its purpose, than that flatterer of vanity a *golden medal*. The good wholesome home-brewed ale, with which it smiles at Christmas and harvest-home, will be much more likely to revive an useful conversation, and a prompt dispensation of its emulating results, than the exhibition of a bauble, whereof  
the

the recollection vanishes with the novelty, and whose only remaining worth can be estimated by the jeweller.

## IRRIGATION IN CHESHIRE.

The practice of irrigation by Mr. Fenna\*, of Baddy, near Namptwich, in Cheshire, is very similar to the method used by the German settlers in America, in the irrigation of meadows with liquid manure.

The farm-house and yard are situated upon a stratum of clay and marl to a considerable depth, and therefore the water, in rainy seasons, is not much decreased by absorption. The sap from the dunghills, and moisture from the cowhouses, &c. is collected into reservoirs. The moisture from the washhouse, stables, pigsties, necessary, &c. which only runs during rain, and a few hours after, is distributed into the first field by a gutter called the *first level*. This farm-house is said to be unfortunately situated upon the highest ground, with a declivity

\* See Communications to the Board of Agriculture, Vol. II. p. 334.

from it in all directions, which prevents any additional water being brought to it by collecting gutters; and therefore the whole quantity here used is what falls from the clouds upon the buildings, yard, &c. being about two acres of ground; and yet this, inconsiderable as it is, promises to be sufficient for the maintenance and improvement of about eight acres of land for mowing or pasture. The wash from the yard, previous to its being used for floating, proceeds, by means of carriage-cutters, to the lands to be irrigated. It is thence distributed into successive zig-zag trenches, which are carried across the lands which the line of level pursues. This form of trenching is adopted in order to keep an equal level across the ridges and furrows, which the former state of constant ploughing has left irregular on the sides or slopes of the declivities, so that the trenches may be of no greater depths or dimensions in the ridges than in the adjacent furrows, or what, in Cheshire, are called *reens*; and that each level may, when charged with water, discharge it equally over the lowest edge of the trench, from one end to the other at one and the same time.

The

The gutters which are cut in this first field are, at the end where they receive the water from the carriage-gutter, eight inches wide at the top, and six inches deep, sharp at the bottom, or of no breadth, commonly called a prickt-gutter, gradually tapering to the extremity, where it is no more than four inches wide, and four inches deep; they are cut across the declivity of the field, at the distance of ten or fifteen yards from each other. The sod, taken from a gutter of this sort, is prismatic or wedge-like; and one of the largest, at the end adjoining the carriage-gutter, is retained and used for a stop, and placed either in the collateral level, or the carriage gutter, as occasion may require; the others have here been chopped to pieces, and spread in the furrows or *reens*, in order in time to make the field more upon a level. Where not wanted to level hollow or low places, they should be carried into heaps and mixed with dung for a compost. There is no part of any gutter raised by the stuff taken out, and therefore the mower meets no more obstruction than he did previous to their being cut.

*Method.*

*Method of floating the fields. 4*

When it rains, the reservoirs are pounded up as high as they can be, without injury to the yard, whilst the rains from the other side of the buildings, including the wash from the washhouse, pigsties, necessaries, &c. are collected into one gutter, or deep ditch, and turned into the first level by the stop; which level becomes thus filled from end to end, and flows down the declivity of the field: but the tendency the water has to quit the ridges, makes it necessary to cut a small channel in each ridge, two inches wide and two inches deep.

After passing over the slope, or part immediately below the first level, it is again collected by the second level, and dispersed over its flat; and in the same manner over the third, fourth, fifth, and sixth levels. But when the water is wanted for another meadow, one of the levels, suitable thereto, becomes a collecting gutter, and by a proper removal and management of the stops, its contents

14





contents are poured through the gateways a a a a, into the field for which they are demanded.

Thus each level and field is alternately managed as occasion requires ; and, one or two days after the rain shall have ceased or abated, when the surface of the field appears dry, the reservoirs of black thick water are let out and distributed where they are needed most. The reason why these were not let out sooner was, the quantity of rain happening to fall might, perhaps, have carried it off over the ground ; and the reason why it should not be used later, or in dry weather, is, the ground is then open and porous, and the reservoirs do not hold a sufficient quantity to reach far upon the field.

Thus it appears that a due observance of the declivity and points of distribution, will render the same gutters and trenches, duly managed by the stops, alternately works of irrigation and drainage ; and, a similar attention to the stops, will either distribute the water through the successive levels, or partially to any which you would use for irrigating by the continuance of the carrier-trench, and turning off the needless levels of the time.

The

The declivity allowed to these levels is an inch to every ten rood: this is sufficient to carry forward the water through its various operations. Hence you may either flow the whole levels and fields in succession, or you may flow the fields in rotation, according to the number of them which are connected with your works.

In other fields, on the estate of Mr. Fenna, we find he contrives to collect water in the time of rains, from all the grounds which lay upon a higher level than those which he designs to irrigate. This method should indeed be observed in all cases of irrigation; for by means of suitable catch water-drains along the sides of more elevated lands, leading to reservoirs dug on eligible scites, it is very practicable to irrigate lands, either with simple or compound liquid, although there be not any other water to resort to than that which falls from the heavens.

Gentlemen who wish to pursue this method of irrigation, with minute attention to the system practised by Mr. Fenna, will do well to refer to this gentleman's detail description, as communicated to the Board of Agriculture. It is to be lamented that we  
are

are not fully favoured with those results of his crops which authorise computation. I have endeavoured to give his principles succinctly, but sufficiently to authorise an imitation, which will necessarily vary according to the circumstances connected—and genius must be greatly relied on. I take the liberty of recommending, however, the employment of an engineer, who has made these points his study; and I have no hesitation in foretelling, that the result will return an ample compensation for the aid of professional skill.

#### IRRIGATION IN GLOUCESTERSHIRE.

In 1789, the Reverend Mr. Wright published a small, but valuable pamphlet, on the art of watering meadows, as it is practised in Gloucestershire. This was printed at Cirencester, and as I have been fortunate enough to procure a copy of it before I close my work on this very interesting topic, I will endeavour to distribute the principal points of his communication to the farther advantages of agriculture.

In the preface of this useful little work, the author, very properly, goes into a previous explanation of the terms of art which are applied to describe this science in Gloucestershire; for it is to be lamented, that terms of art, as well as provincial phraseology, are not yet reduced to any uniform standard within the sphere of a modern dictionary.

The *works* (says he) are the large ditches, by which the water is introduced into the meadow.

The *trough* is a smaller ditch, which branches from the works.

The *stop* consists of one, two, or more stakes, driven down in the middle of the works and troughs, to obstruct the course of the water, and to keep it high enough to flow through the sluices.

The *sluice* is a small aperture made in the sides or banks of the works and troughs, at the distance of one or two yards; and through which the water passes that covers the surface of the land.

The *drains* are ditches cut in various directions, and different dimensions, resembling the branches of a tree, and all terminate

minate in one large trunk, which carries the water back into the stream.

The advantages (says he) arising from this mode of watering are many and great. If it be well executed, I may freely venture to assert, that this mode of cultivation will be found more productive than any modern improvement in agriculture. By it land, whatever its kind or quality, is increased to *double or treble* its former value. And it does not derive this enriching power from the assistance or spoil of the neighbouring lands, but it diffuses a general fertility. It does not rob the farm-yard of its stores, nor even take back from the abundance which it there produces; for it stands in need of no dung, no expensive preparation of manure or compost. So that the farmer, who occupies fifty acres of this watered land, has an hundred tons of hay to carry off and spend upon his other grounds. But it is not merely the crop which constitutes the excellence of watering; it is the *earliness* and *certainly* of the crop.

Every intelligent farmer is sensible of the great value of grass very early in the spring; and we, by watering, have plenty of grass at the beginning of March, and when the

season is mild, somewhat earlier. The good effect this grass has upon cattle that have been unhealthy or hard-wintered, is astonishing. The second week after turning into the meadows, a very visible change is made in all cows, horses, and sheep: and the farmers are here enabled to begin cheesemaking at least a month sooner than their neighbours, who enjoy not the benefit of watering their land. And in fattening of lambs, the value of grass is inestimable.

With regard to the certainty of a crop I need not say much; the thing will speak for itself. Between March and May we are sure of spring-feed that is worth, at least, a guinea per acre; in June we have a crop of grass that will yield two tons of hay per acre; and the latter-math is always worth a pound. Let the summer be ever so dry, we have nearly the same quantity. After the last dry summer, the advantage of watering was evident; for the neighbouring farmers were obliged to come hither to buy hay, at whatsoever price the owners thought proper to demand.

Other advantages of watering there are which ought not to be passed over unnoticed. The land thus treated is continually improving;

proving; its herbage, if coarse, is fined; its soil, if swampy, becomes sound; and an addition is made annually both to the depth and quality of its mould.

As a kind of proof of some of the above assertions, I shall thus instance the product of one of our meadows this present year. It is one that has been watered longer than the memory of the oldest man in the parish; but it is by no means the best meadow upon the stream, nor has this year been a favourable one for watering. It is about six acres and a half. The spring-feed of it was let for seven guineas, and well supported an almost incredible number of sheep (an hundred and fifty), for two months; the hay was sold for thirty-two guineas; and the latter-math for six.

Mr. Wright then proceeds to a preference to muddy or saturated water, which Mr. Boswell, I find, contests in favour of *limpid* water: possibly both may be right under a difference of circumstances. I shall therefore pass over this particular, referring those to a comparison of their reasonings who may wish *chemical* satisfaction on this head; it appears pretty clearly, I think, that the practical facts are good in both instances

and practical experiments will be the best guides on every variety of soil and situation.

Mr. Wright states the quantity of land irrigated in his parish to be three hundred acres; and the stream, from whence the water is drawn, to be mostly equal to a section of five yards by one—but seldom to exceed such dimensions.

The three following things, this gentleman tells us, are necessary to be considered:

1. “Will your stream of water admit of a *temporary*\* wear or dam across it?”

2. “Can you dam up and raise the water higher than any part of your meadow, without flooding and injuring your neighbour’s land?”

3. “Can you take the water off your meadow as quick as it is brought on?” And he might have added, in regard to the present improved knowledge of mechanical powers,

4. Can you apply machinery, moved by wind, by water, by steam, or by animal

\* Mr. Boswell, in his Treatise on Water-Meadows, p. 116, objects to TEMPORARY wears; for reasons which appear to have some weight in respect to subsequent injuries from their remains. Much in this case, I think, may depend on the quality of the soil and wear labour,



labour; as the power of motion, to convey water over your land, at an expence which will bear a light proportion in the scale of preponderating profit?

If you can answer such of these questions in the affirmative as apply to your particular case, I have no hesitation in saying you ought to proceed immediately to erecting works for agricultural irrigation; and if you do not do it, you will repent every year's neglect.

In this case, if you prefer the Gloucestershire method, you will conduct the water along the highest part of your meadow, by means of a deep wide ditch, such as they term the *master-work*, the banks whereof should be of an equal height, and a few inches higher than the general surface of the meadow. In large meadows, such works must be repeated according to the divisions of the ground. These ditches should be about nine feet wide, and a proportionate depth, to a plat of about fifteen acres. And these works are sometimes repeated in number, so as to give successive waterings to larger tracts.

Smaller *ditches* or *troughs* are to be cut from these, at nearly-right angles, and their

respective widths to be, of course, proportioned to the distance they are to be carried, and the demand of the part to be irrigated.

The distance of these ditches from each other should be about ten or twelve yards. Ten yards wide upon the surface may be watered by a ditch of two feet wide, and one deep. Mr. Wright limits these kind of troughs to forty yards long; but, if the supply of water is sufficient, I see no difference between the distance of forty yards and forty miles, where repeated communications can be made with the work. In each of these troughs frequent stops are to be placed, especially where the water is rapid, in order to keep it high enough to flow through the sluices, or over the sides.

It is obvious that the works and ditches, or troughs, may be diminished in their progress downwards; for this operation, which distributes water to a thirsty soil, which retains a proportion as it passes, is evidently the reverse of the operation of drainage, which draws off the superabundant supply of moisture, in a state of continual accumulation; and requiring a wider sewer in its progress towards the sea, upon precisely the same principles of ramification which nature has

has employed in the formation of rivers. Wherever the water seems inclined to stand, a drain or narrow ditch is to be immediately cut into the main drain which carries off the water.

In cold flat, swampy meadows, Mr. Wright says that the distance between trough and drain ought never to exceed four or five yards. The fall of the ground he also regulates at half an inch per foot for meadows. He says the water should never flow more than two inches deep over the land. When the grass is two inches high, he is of opinion the water should never shew itself, except in the ditches. I apprehend, however, that in very thirsty lands or warmer climates, it will be better to resort to a little local experience, than to confine the operation to the obstinate rule of a limited spot. In this respect, when Gentlemen think proper either to send their own farmers to learn the art in an irrigated country, or to employ a professional irrigator from thence, I would recommend the addition of their own judgment on the principles of natural philosophy. In hot countries I have had sufficient experience to convince me, that few grasses  
will

will stand watering under the immediate influence of the sun ; but if you suffer the sun to go down, and avail yourself of that moment to irrigate your lands with an hour or two's flow of water, taking care to turn it off at the expiration of that time, you may safely, I think, use this mode of irrigating grass, and perhaps grain, throughout the earlier stages of vegetation, until it appears to be time to let the natural process of ripening commence. A method of this kind will furnish a pearly dew every morning through the heat of the summer ; and I take that to be a degree of moisture which is the most agreeable to the natural requisitions of the vegetative principle.

Sometimes, Mr. Wright tells us, it is necessary to carry the drains under the works and troughs, in order to get rid of the surplus water after it is used. In this case, it is the practice in Gloucestershire to make use of boards, and boards and planks, for conveying the water above in the manner of an aqueduct over a river ; and this is here termed a carry. For the better regulating the distribution of the water in spring, it is also customary to dig small temporary trenches  
where

where they seem to be most wanted, laying the sod or mould by the side of them, that it may be replaced when the watering is over. In replacing this sod, the irrigation should always look forward to the scythe, so that this may not prove a future obstruction to mowing.

Mr. Wright speaks of grounds which have been ploughed into broad lands and furrows as the best shape for irrigation; because such shape admits of conveying the water quickly along a small ditch upon the ridge, and passing it off by the furrow.

Every meadow should therefore be brought into this shape, according to his recommendation; though it is sometimes necessary to make three works, one across each end of the land, and one diagonally. It is clear to me, however, that genius and experience must be employed in this respect, according to the nature of each particular case.

When the lands are thus prepared for irrigation, the Gloucestershire method of applying the water is as follows: in the beginning of November they cleanse all the works, troughs, and drains from grass, weeds, and other impediments; and repair the banks, if they are injured by the feet of cattle or other casualty.

casualty. The opportunity of the first shower is then seized on, for the purpose of irrigating with as much muddy water as possible; the richness and salts, which the waters are supposed to contain in greater abundance at this season, are thus deposited as a manure to the impoverished soil, and the water taken off in about three weeks.

The Author of a late History of Cirencester, who has followed a later edition of Mr. Wright's pamphlet than I have seen, says, that in December and January care is to be taken that the land be sheltered by the water from the severity of frosty nights. But it is necessary through the winter, every ten days or fortnight, to give the land air for a few days, by taking the water entirely off, otherwise it would rot the roots of the grass. And every meadow should be surveyed twice a week, to see that the water is equally distributed, and to remove hurtful obstructions from sticks and weeds.

In February much caution is necessary, if the water remain on the meadow for many days without intermission, as it will generate a white scum, very destructive to the grass. On the other hand, if it be taken off, and the land exposed to a severe frosty night, without

without being previously dried for a whole day, it will cut off much of the tender grafs. To avoid these injuries, take the water off by day, to prevent the scum, and turn it over at night, to guard against the frost; or both may be avoided, by taking the water off entirely for a few days and nights, provided the day on which it is taken off be dry; for after one fine drying day, a frost at night will do the grafs little or no injury. Towards the middle of this month, use only about half as much water as in the winter. Rather wet than water; for at this season it is only necessary to keep the land in a warm humid state, to force vegetation.

At the beginning of March there is generally on such meadows abundant pasturage for all kinds of stock. But the water should be taken off for nearly a week before heavy cattle are turned on; and if the season be cold, it is proper, during the first week, to give the stock a little hay at night.

Some persons eat off the spring feed with ewes and lambs, by enclosing them with flakes or hurdles in a certain portion of it every day, giving hay at the same time. This is certainly making the most of the grafs, and an excellent method to fine and sweeten

sweeten the future herbage. In March and April the grafs may be eaten as short and close as possible, but never later. If the month of May be trespassed on for only a week, it will very materially impair the hay crop; the grafs will be soft and woolly, like latter-math.

When spring feeding is finished, the water is again necessary for a few days by way of wetting.

It is remarkable, that watering in autumn, winter, and spring, will not occasion the rot in sheep; but has been known to remove the cause from meadows which had rotted. But if the water be used, though only for a few days, in any of the summer months, the pasturage will be unsafe for sheep. Take one instance: at the beginning of July, the hay being off, and the river very muddy from abundant rain, the water was thrown over a meadow for ten days; in about a month the ground was covered with an uncommon luxuriance of herbage, into which eight found young ewes, and two lambs, were turned to depasture: the lambs were killed six weeks afterwards, and had symptoms of rottenness; and in about a month or six weeks more, the ewes were also killed, and



and though they were very fat, their livers were putrid, and replete with the insect called the fluke, or weevil. This experiment ascertains the event, and, at the same time, proves that muddy water in the summer is much richer than in the winter or autumn, and may be very advantageously used, for a week at least, every wet summer, notwithstanding the inconvenience as to sheep.

All objections to watering meadows after this method, such as cutting the ground, laying out meadow, and other expences; that hay thus produced is inferior to upland hay, &c. are abundantly countervailed by the advantages. The coarseness of the hay is obviated by cutting early, when it will be excellent: but those who are covetous of having nearly three tons to the acre, must be content with long, coarse hay.

The advantages are, the land and herbage are continually improving, without manure; the crop is not only full and certain, but it is also early. And who is not sensible of the astonishing effects of early grass on all sorts of cattle, but particularly sheep and lambs?

With

With these advantages, it is surprising that the practice has not long since become general throughout the kingdom. In this neighbourhood the most insignificant spring or rivulet is not suffered to pass unrestrained; and whenever a sudden shower occasions a temporary flood, proper ditches are made to receive the water, and to spread it equally over the land; but there is no stream or river on which a mill is or can be erected, but what may be made very enriching to a certain quantity, if not a large tract, of land.

In levelling a work for irrigation, care should be taken to proportion the current to the distance: for example, if the distance is one hundred yards, and the fall four inches, then it is one inch fall to each twenty-five yards, and so in proportion.

*Expla-*

4

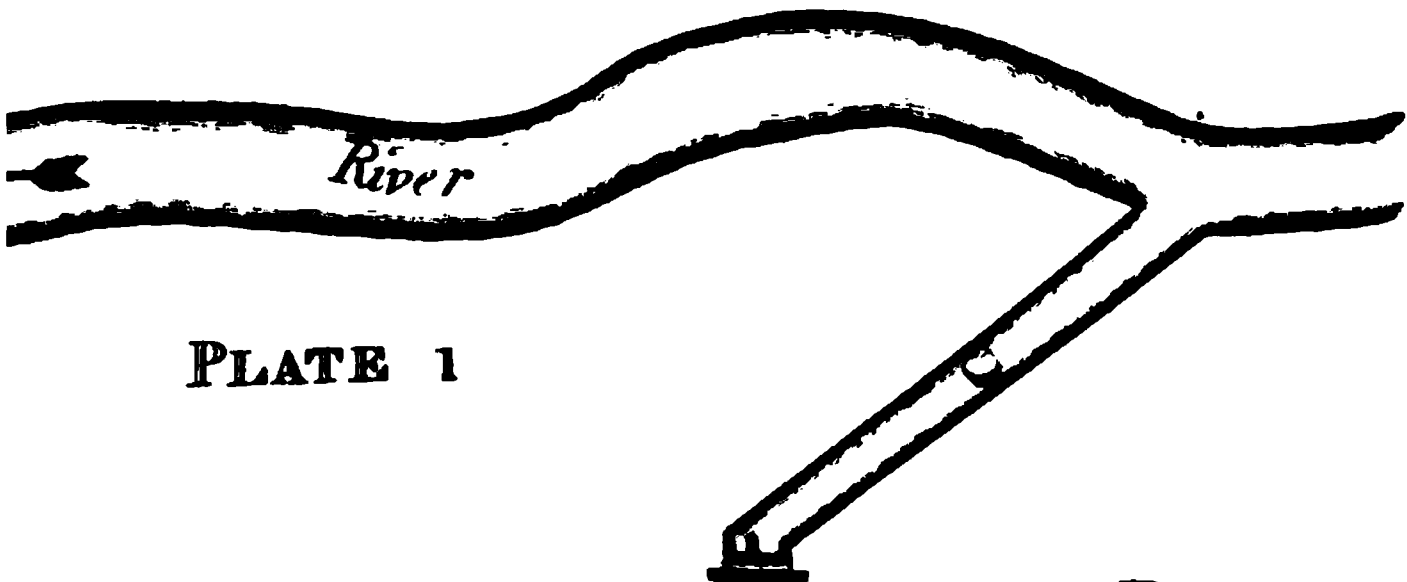


PLATE 1

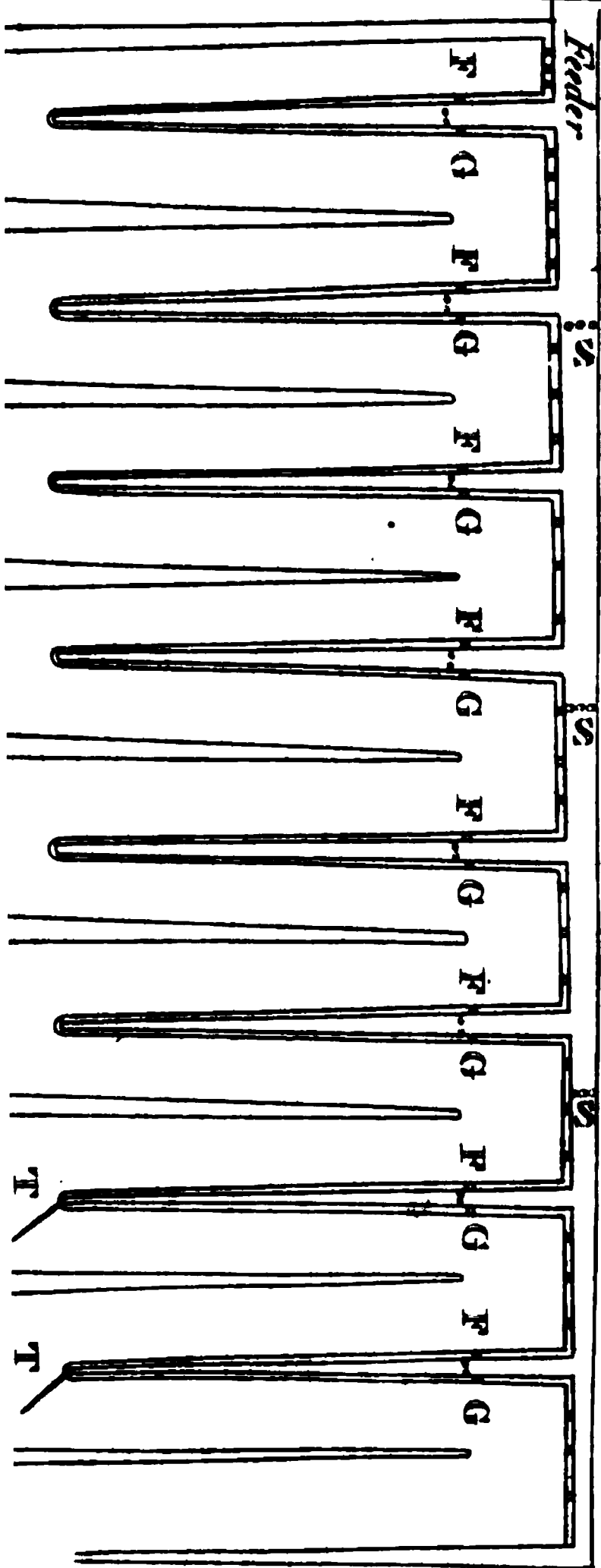
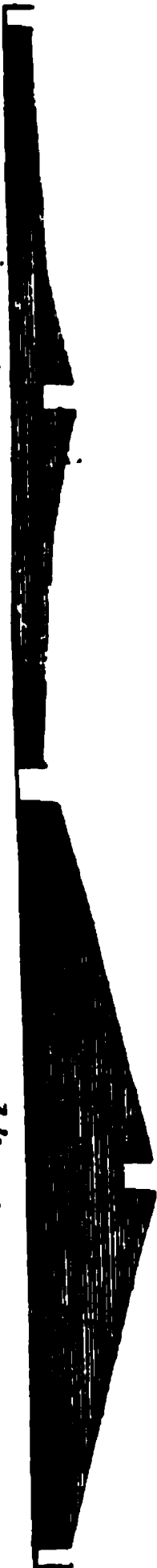


Fig. 1.

Fig. 2.



cutting pump

*Explanation of the annexed Plates, from  
the History of Cirencester.*

PLATE I.

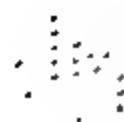
Represents a meadow regular in its surface with the current of the river, but too high to be floated from the part of the stream immediately opposite to it. In order, therefore, to gain a fall, the water is taken out at a higher part of the stream by a conductor, as at C, into the feeder, which is cut along the highest part of the meadow, and has a flood hatch in the mouth of it, to admit or exclude the water at pleasure. This conductor we will suppose, for the sake of illustration, has only four inches descent in its whole length, but the stream in the same length falls ten inches; therefore, six inches of power are gained by means of the conductor, which is a fall abundantly sufficient for floating the meadow. By this mode of gaining descent, thousands of acres may be floated, which some would think impossible to be done.

Fig. 1 and 2 represent a transverse section of two ridges, with their sides or beds an inclined plane. The floating gutters, or troughs, as we sometimes call them, (marked F. G.) are drawn with double lines; and the stops in these and the feeder are marked with small circles and the letter S. The drain cuts are made with single lines.

## PLATE II.

Represents a floated meadow, which had three parts considerably higher than the general surface of the land. In order to throw the water over the higher parts, it was necessary that each should be accommodated with a separate feeder, as shewn in F. 1, F. 2, F. 3, with its stops, gutters, notches, and drains. In this method the floating may be alternate through the winter.

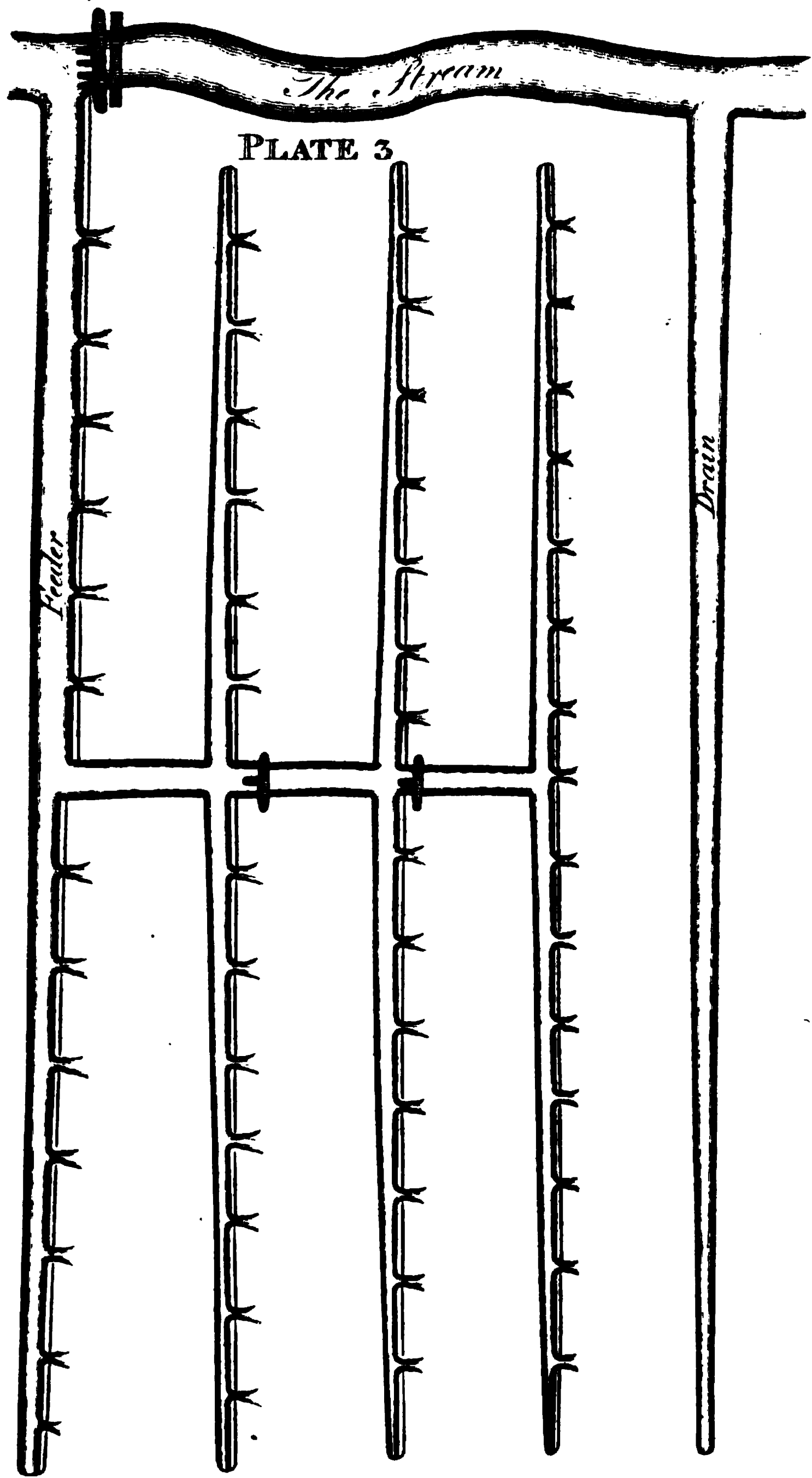
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Carton 10/10

44







## PLATE III.

Represents a sort of floating commonly called *catch-work*, where the ditches are made at a distance below each other, across the declivity, to catch the water, again and again, from the top to the bottom of the meadow. It is evident that the upper beds must receive more than their share of the nutriment that is deposited. This method should never be used but where the declivity is too great to admit the floating gutters to point down the descent, as in the other method.

In December and January, says Mr. Wright, they are careful to shelter the lands from frosty nights, by keeping the water flowed over it. In February they enjoin a more particular care not to let the water remain many days, on account of a white scum which arises, and is very injurious to the grass; and the danger of killing the grass by the frost at this season.

The only way to avoid both these risks, Mr. Wright says, is to take the water off in the day, and turn it on at night; for it is only when the grass is wet, that the frost is so pernicious.

Mr. Boswell, on the contrary, condemns this doctrine, and says, that although the warmth of the sun is seldom sufficient to have an effect upon the water in the month of February, that it is not uncommon in that month to have the waters kept upon the meadows for a fortnight or more; and that as the frost sometimes freezes up the hatches or flood-gates in one night, meadows are covered for several weeks with ice; and that when the frost is gone off, those meadows always shew the finest verdure sooner. I  
incline

incline to coincide with Mr. Boswell on what I have remarked in regard to a crop of wheat being covered with snow, as a shelter against the chilling blast ; and for some other reasons which are better explained in my two papers, published in the two Numbers of the Monthly Magazine, for the months of February and March last, on the causes which affect the climate of North America: yet I am loth to distrust Mr. Wright's observations, and am rather disposed to believe that there is some oversight in the business, or some unobserved principle or other which might reconcile their seeming contradictions.

Mr. Wright seems to think, that as much water as will cover the surface barely, is sufficient at this season. Mr. Boswell thinks otherwise. At the beginning of May, just after the spring feed is eaten down, the meadows are to be irrigated ; and the same should be done after taking off the hay. I myself have a tract of land in the Tennessee country in N. America, upon which I resided during the hard winter, 1779-80. On this tract was a small piece of upland meadow, of the kind of grass known in America by the name of *Timothy*, but the English name of

which is unknown to me \*. The snow was at this time and place nearly ten inches deep; and so frozen, for nearly ten weeks without intermission, that the waters were closed up, so as to produce an amazing destruction of outlying cattle and horses; the deer and other game suffered almost an extirpation in many of the nearest hunting grounds; and, without exaggeration, the wild turkies were so tamed from the trees, as to feed among the poultry at the cottage doors. Even this severe frost had no effect on the Timothy grass; or, at most, a very partial one; and the herbage of the meadow made an early and luxuriant appearance on the approach of spring.

I have not been able to come at Mr. Blythe's work, the *Improver improved*, of which Mr. Boswell speaks highly, as a useful book on Agriculture, and in respect to its general information on the subject of irrigation. But I shall endeavour to draw from the latter some of those useful lights which may be reasonably expected from so able a practical farmer.

\* Since writing this, I observe Mr. Strickland supposes it to be the *phleum pratense* of Withering, variety *nodosum*.

This gentleman adopts Mr. Kent's maxim, in which all the practical farmers we meet with seem to concur; and many of them adduce the most satisfactory proofs of its solidity\*. "*Flooding is truly the best of all improvements, where it can be effected; and there ought not to be a single acre of land neglected which is capable of it.*"

Mr. Boswell, speaking of the kind of lands which are *capable of being watered*, goes into qualities of the soil, and circumstances which seem proper subjects of information to practical irrigators, who should endeavour to know every thing. In regard to the proportion of lands which may be watered, he seems to confine himself to those principally which come either under the level of nature, or require very little assistance of art. But as my idea of adopting *national machinery*, is competent to humble the mountain top to the offices of aration, I shall pass this part over.

It seems proper to take notice of the various implements of irrigation which are used in Dorsetshire, according to Mr. Bos-

\* Kent's Hints to the Landed Interest.

well's method of watering. He enumerates the water-level; the line-reel, and breast-plough; spades, peculiarly adapted to irrigation; the crescent; wheel-barrows; hand-barrows; three-wheeled carts; scythes; forks; long-tined crooks; stout large water-boots. I shall venture to give his explanation of such as are out of the course of ordinary observation; using my own remarks where I think an advantage may not have occurred to him.

### *Water-levels.*

As the science of levelling is reduced to mathematical nicety, and a great variety of instruments are now in use among professional engineers, such as every gentleman should employ where he means to render his works permanent and effective, I shall only notice such rules of conducting the levels of irrigation as are commonly observed by the workmen. The workmen, Mr. Boswell\* says, dispense with the use of the instrument,

\*.Boswell on Water Meadows, p. 16.

bringing



bringing the water after them to work by. In drawing a *main*, they begin at the head, and work deep enough for the water to follow them. In drawing a *tail drain*, they begin at the lower end of it, and work upwards, to let the *tail-water* come after them. —This method obtains the exactest level.

*The line, rule, and breast-plough.*

I shall say nothing of the two first, which are known to every body. The breast-plough is an implement used in the agricultural office of *burn-beating*, or *denshiring*. It is formed somewhat in the manner of a spade, with broad wings suitable, to take a good width of sod or swarth; for the getting whereof it is much used in the County of Lancaster, and other turf countries. It is fixed upon a long handle or helve, with a cross handle and breast-piece to rest against the breast of the man, who uses it by pushing it forward before him. By giving the blade of the spade a suitable shape, it may be also used to advantage in clearing out the bottom of drains, ditches, &c. There is a  
similar

similar implement used, in Lancashire, in a different way, by pushing it with the thigh, against which a large wooden head or button is so contrived as to rest.

### *Spades.*

The stems of spades for irrigation are considerably more crooked than other spades ; so that the workman, in the bottom of the ditch, may be able to make his drain or trench smooth and even, when standing in a working position. The bit is made of iron, about a foot wide in the middle, terminating in a point, having a thick ridge down the middle, and thin and sharp on the edges : when worn thin and narrow, these are used for the smaller trenches, and others are replaced for the larger.

### *Crescent.*

This instrument is made like a gardener's edging knife, but larger, in the form of a crescent, very thin and well steeled, having  
a stem

a stem about three feet long, with a cross-handle to bear upon. Its use is to trace out the sides of the mains, trenches, drains, &c. which, Mr. Boswell says, it does very expeditiously, and with ease to the workmen, where the land is free from stones.

### *Wheel-barrows.*

Those for this use are made *open*, without sides or hinder part. They are principally for conveying fods, &c.; for embanking, damming, &c.

### *Hand-barrows.*

Where the ground is soft and flooded, it becomes necessary to substitute these in lieu of wheel-barrows, for conveying clods of earth, &c.

*Three-*

### *Three-wheeled Carts.*

These appear to be in use in Dorset; and I presume with a broad tread or tire. Their utility in water-meadows is obvious; as the wheels do not follow each other in the track, and as a proportion of the weight is borne upon each wheel in a triangular form, which will be less subject to cut and sink into the soil.

### *Scythes.*

Both short and narrow scythes are implements of frequent use during the running of the water: they are then used to take away the weeds and superfluous grass.

### *Forks and Crooks.*

These are constantly wanted during the times when it is necessary to clear the drains of weeds and roots. The crooks are formed  
with

with long tines for this purpose, similar to a dung-dragg. These should be made light and with long stems, so that the workmen can reach into deep water with them, to clear the stream from obstructions.

*Stout large-topped Boots.*

The tops of these should draw halfway up the thigh or better; they should be stout leather, well greased with tallow, so as to resist running water for ten or twelve hours together; and should be large enough to admit of stuffing them down with hay all round the legs. The watermen's boots used in the New England and Newfoundland fisheries, would apply well in this case. There are several other implements that Mr. Boswell has not noticed, which appear to me to apply well to the management of water-meadows, where there are hedges, woody countries, briars, &c. — Such, for instance, as *sprouting-hoes*, *weeding-hoes*, *briar-hooks*, *mole-rakes*, *duck-crows*, *gripes for drawing weeds*, *horse-sleighs*, *turf-spades*, &c. which, I think, will often be found

A *trunk* is literally a covered sluice, and is so constructed in all cases where two streams of water are to cross each other at the point of discharge, or if it is to serve as a bridge.

A *carriage* is a small species of wooden or brick aqueduct, built open, for the purpose of carrying one stream over another. Mr. Boswell considers this the most expensive conveyance belonging to watering.

A *drain-sluice*, or *drain-trunk*, says Mr. Boswell, should always be placed in the lowest part of some main, as near to the head as a drain can be found that is situated low enough to drain the main, &c. It is placed with its mouth at the bottom of the main, and let down into the bank, and from its other end a drain is cut to communicate with some trench-drain that is nearest. This contrivance is used to carry off the leakage through the hatches when they are shut down to convey the water to other grounds, or to repair the main, &c.

*Hatches* seem to be literally another name for flood-gates, and applied to the same purposes; they may, of course, be variously constructed. Mr. Boswell uses a particular kind, with about a foot to take off, so as  
to

to permit the water to flow over that much of the hatch where it appears to be useful in irrigation. This method might, I think, be improved by constructing the hatches in the manner of the kind of Venetian-shades which turn upon an axis.

A *head-main* signifies that part of the principal ditch which takes the water first out of a river or stream, for the purpose of distribution through its smaller ramifications.

*Small mains* are the next gradation of ditches which are applied to distribution, by means of their communication between the head-main and trenches. These are, by some, confounded with other works, by the term *carriages*.

A *trench* is the last distribution-ditch in watering, continuing to decrease its dimensions as it spreads the water over a greater extent of ground.

A *trench-drain* is a deep ditch or drain which meets the trenches, for the purpose of taking the water away speedily after the irrigation is performed. It should be cut parallel to the trench, and as deep as the tail-drain water will permit; if possible so as to reach the stratum of sand, gravel, or clay—a spade's depth into the last would be an ad-

vantage. Its gradations are exactly the reverse of the trenches, which it meets in the manner of two forks, placed with their points into each other at regular distances. Its parts, of course, increase as it receives successive streams to be drained off.

A *tail-drain* is the principal ditch which conveys the water out of the meadow. It receives that which all other drains discharge, and should consequently lead to the lowest possible point of discharge, and the nearest direction which the ground, under every circumstance, will permit. If used as a fence-ditch, this answers a double purpose.

A *pane* of ground signifies the part containing the grass to be mown between the trench and trench-drain: each of such strips of land are called a *pane*.

A *way-pane* is the strip of land left for cartage, along the side of the main, being watered from the banks of the main, and drained by a parallel ditch.

A *bend* is defined by Mr. Boswell to be, a stoppage made in various parts of those trenches which have a too quick descent, in order to check the water and force it out of the trench. This is done by leaving small  
dams



dams of the natural sward at proper places, and cutting a sod out of them wedgeways; so as to limit the impetuosity of the current and give a more equal distribution of the water.

A *gutter* is a small groove cut from the tails of the trenches, occasionally, to distribute the water to the utmost extent of the panes more equally than could be effected by the regular works, so as by this means to avoid patch-work or omissions.

A *catch-drain* is an occasional ditch which is sometimes cut to carry the same water into a second main, for the purpose of irrigating a lower meadow or pane with the same water which has been used. The watermen consider it then, however, to be in an impoverished state, on account of the particles just deposited, or communicated to the lands above.

A *pond*, in irrigation, is applied to any spot of stagnant water, which is left on the ground in the process of irrigation, to the detriment of the crop.

A *turn* of water, signifies as much as can be distributed at a single operation, by the management of the hatches within reach of

the labourers employed, and as the stream will support.

The *head* of the meadow is that part into which the *main* first enters.

The *tail* of the meadow, being the reverse, is that part where the tail-water last passes off by the tail-drain into the natural sewer; or where that sewer itself leaves the meadow.

The *upper* side of the meadow, is that which fronts the point at which the main or river entered.

The *lower* side is, consequently the reverse of the above.

The upper *pane* is that which lays above the main, if such a one be left.

As gentlemen who incline to irrigate their estates will, doubtless, procure the aid of practical men, and experienced examples as far as possible, I shall forbear to go into farther detail of the practice in irrigation as adopted in Dorsetshire.

There have been some objections raised against irrigating by art, in the manner practised in Gloucester and Dorsetshire; but I think these have been founded on a superficial view of the subject, and I agree with  
Mr.

Mr. Wright in the arguments which he uses to refute them. If it is said that much land is wanted in cutting the drains, trenches, and mains, may it not be asked, with propriety, if the land does not produce three times as much grass as before; and if this is not to be considered among the most interesting kinds of gain which can be added to annual income?

If it is said to be expensive; let me ask, if the money thus sunk in ameliorating the farm, does not return a better interest, and a more permanent one, than could have been obtained for the same sum elsewhere?

If it is said that the hay of these meadows is not so good as others; it may be replied, that *the best proof of a pudding lies in the eating*: for Mr. Wright assures us, that he has seen a cow, fatted wholly with this hay, which sold for twenty pounds\*.

Some again, it seems, have raised an objection to paying millers for the use of water. If this were a general case, it would apply with some degree of weight, but not insurmountably. Mr. Wright gives as a

\* Wright on the Water Meadow of Gloucester, p. 14.

proof of this, that one meadow of sixteen acres, in his parish, pays six guineas per annum to a miller for the use of his water ; and if the proprietor did not find his account in it, he would certainly decline it. My plan for national irrigation, not only removes this objection totally, by taking water from lakes, ponds, and rivers, but goes to assist both the miller and navigable canals with surplus water ; and may furnish the irrigator with sea water, containing salts in abundance.

If we are permitted, however, to credit the respectable clergyman who has communicated the Gloucestershire mode of irrigating, no man ever yet repented a fair experiment.

The Author of a work just published, under the title of the *New Farmer's Calendar, or Monthly Remembrancer*, a book which it is to be hoped will prove of some importance to practical farming, considers irrigation as a very excellent, though at the same time he says, an expensive and frequently difficult mode of improvement : if the object of a farmer's care, however, is admitted, as in other occupations, to contemplate the greatest and most speedy accumulation of capital stock as its chief end, then expence will prove only a relative drawback

back upon a greater quantity of produce, which gives the cultivator an increase of profit that he could not by any other means attain; and he will find himself possessed of all the benefits of overflow and deposited sediment, which the Remembrancer confesses, without dreading those difficulties which judgment and perseverance are competent to conquer.

Although this writer, as he acknowledges, has never paid much attention to the practice of irrigation, he has certainly hit upon some of its best principles, in applying it to the growth of the crop, or the amelioration of the soil: the chemical virtues which it imparts to the earth are doubtless to be admitted as a gratuitous manure, which might otherwise become wasted, or generate nuisance: and I heartily accord in his regret, that any spring or river in his majesty's dominions are suffered to waste the most material particles of nature's fructifying medium, when the various streams might be easily distributed to the respective calls of irrigation, without depredating the ordinary properties of their pre-existing functions. The Author of this Calendar estimates the irrigation of an acre of meadow at a sum which would go far to

overturn my system ; yet it is the object of my system to overturn his expence ; and we may perhaps ultimately be both of us right in this seeming contradiction. An acre of meadow land, he says, will cost from three to seven pounds to prepare it ; that is, between three and seven, or an average of five pounds for each acre of a farm, I presume, which an individual undertakes to irrigate, including command of water ; and, consequently, this expence must be repeated in the undertakings of each and every individual. Yet if the *nation* were to undertake a *system of irrigation*, I apprehend the repetition of the heaviest items may be avoided ; and the beauties of Mr. Adam Smith's chapter on the distribution of labour would be astonishingly exemplified. The illustration which this Gentleman has chosen, by adopting a select instance of improvement in Gloucestershire, will, in any event, add strength to my proposition, by the demonstration of profit. On the 2d day of April, says he, 107 sheep, 8 cows, and 7 colts, were fed on a piece of old watered meadow of eight acres, during five weeks ; that is to say, until the time of shutting up for the hay crop, for the keep of which the proprietor

ctor received £.35 1s. 10d. after the rate of 10d. a head per week for the sheep, 3s. 6d. for the cows, and 4s. the colts. The crop of hay was afterwards about fifteen tons, which was six weeks in growing.

Such a profit as this, is, I apprehend, seldom drawn from commercial capital ; yet it should be remembered, that irrigation gave this as a specimen of permanent production ; not barely of rent, which, like commerce, might be uncertain, and subject to a fluctuation of proceeds according to the tide of fickle prejudice, or capricious opinion.

In cases where permanency of situation, and durability of materials, are objects of moment, or where the preference and circumstances of the party may justify a proportionate expence, the hydraulic machine, upon an improved *Noria* principle, which is now offered to the public by Messrs. Dixie and Maplestone, at their Factory in London, may be usefully applied, and increased to any given size or capacity.

The one in daily use at their factory is forty feet elevation from the lower level to the bottom of the upper cistern ; and, it is said, it can raise one hundred gallons per minute

minute by one man's labour. The buckets are made of elm, fitted upon two ropes; so that one bucket serves as a cover to the other in their ascent: by which means, I conceive, they may not only be constructed so as to serve each other for lids, but the rotary movement they perform round the drum, pin, or spocket wheel avoids all but the lateral pressure of the atmosphere; which, comparatively considered, can scarce be admitted as friction. This method of avoiding any other resistance than the actual specific gravity, and its progressive accumulation with the increase of distance from the revolving axis, seems to fit this machine more particularly than the Spanish Noria, to many useful purposes, where a great elevation is demanded; though, perhaps, the cheapness of the Noria, and the capacity of many other cheap yet powerful machines that are now in use, have a preference, where only a small degree of ascent is required.

The cost of this machine is five shillings per foot running measure; say ten shillings per foot perpendicular height, besides extra charges, which may perhaps amount to between



tween six and ten guineas more for one of forty feet elevation.

In cases where it may be convenient to use this machine for draining lands from a lower level to a higher, I apprehend the addition of a little expence in respect to a few feet elevation, may be considered economical; for by this means the water, which it becomes necessary to discharge, may be thrown into the buckets of an overshot wheel without the expence of a dam; and, in mountainous countries, may be applied to an extent of machinery, and perhaps to a succession of water-falls, without any extra expence in regard to a first moving power, which may thus be counted clear gain.

It is hence extremely obvious to me, that a very interesting application of this apparatus may be made to many of the great mechanical and manufacturing purposes of Great Britain; and perhaps to those of agricultural irrigation; the feeding of canals; and the watering of cities. There is one great use, however, which occurs to me, in which I think the more wealthy proprietors of houses may profit by the adoption of it into their system of household economy. It has a capacity to spare all the customary  
water

water carrying up stairs, because, by the extension of its distributive pipes, the water may be more easily conducted into every room in the house by the labour of one man, than ten pails, perhaps one, full, can be carried up to the garrets.

In paying a just tribute to the merits of this profitable machine, we should nevertheless remember that the idea is by no means new : Messrs. Dixie and Maplestone are too well instructed in their profession, and too candid to invade the less improved merits of the Noria, or the more antient claims of Costar, who seems to have been the father of chain pumps, and the great grandfather of many improvements in the hydraulic art, which have successively usurped their patented station in the pedigree of mechanic genius ; and in the collateral application of his principles to solid operations.

The proprietors of this useful implement in its present improved condition seem to be contented with manufacturing it with buckets of wood, copper, pewter, or earthen ware, giving preference to pewter for its sweetness and durability ; and they recommend it for the deepest wells, mines, quarries,

ries, coal pits, navigations, breweries, distilleries, &c. for which its rotary movement is particularly adapted.

In Switzerland, they have an invention similar to this, which they apply to a pump by way of valves: a rope is reeved through the bore of the pump, which is left open at both ends; blocks of wood, of an oval figure, are threaded upon this rope in the manner of beads, and are confined to a particular space from each other, by means of knots in the rope, which is formed into an endless strap, passing round a drum wheel below the pump; and round a sprocket wheel above it, this strap pulls the blocks through the pump barrel, forcing the water before it. I have seen it in use in Spain, but the friction is great and disorderly, and I think it better dispensed with.

*Of Irrigation by means of Warping.*

It is much to be lamented, that in the present state of agricultural science, it is not easy for men in general to comprehend many local and technical terms belonging to husbandry, which, properly speaking, are fitting subjects for a Glossary. The reflections of the Board, it is to be hoped, will in due season be awakened by this deficiency; and if their able Secretary could find time to form a more complete Agricultural Dictionary, progressively as words occur, in addition to those which are already explained, it would probably be found capable of fixing a national standard; and would prove a treasure in husbandry. A term offers on the subject I am at present about to notice, which may serve as an example: the word warping, which is technically applied to towing of ships, and preparing webs of cloth for the weaver's loom, is also, I find, applied in agriculture to describe that species of irrigation which deposits a quantity of sediment from the flowing tide, and which forms a

stratum

stratum of soil or manure when the waters have receded from it.

This definition of the word appears to be chiefly limited to tide water flowing from the sea ; though the nature of the accumulation seems to be nearly the same with the siltage of fresh-water rivers, the redundancy of which, by way of distinction, is called flooding.

This operation, whereby soil is created, is said to have originated within a few years of the present time ; and various counties in England lay claim to the discovery, without any degree of acknowledgment to the tuition of Egyptian husbandry. A late work, entitled the Remembrancer, or Farmer's Calendar, attributes the primary practice to the county of Lincoln, while others bestow the laurels on the county of York : but all seem to agree, that although the works are, in the first instance, expensive, there are few, if any, cases where money can be more advantageously laid out.

The fertility of the Nile affords a stimulus to exertion, which should be ever present before the warper ; and I avail myself of a few British examples which Sir John Sinclair has kindly suggested to me, for the purpose of  
of

of rendering this discovery more generally known.

The practice of warping, although one of the most important improvements in husbandry, is so local, so limited in its extent, and so partially understood, that I shall need no apology for dwelling at some length upon the subject: so far, indeed, as examples have occurred through this reference, or in the surveys reported to the Board of Agriculture, I must beg the popular indulgence, and avail myself of the means which are to be obtained for rendering my book more distributively useful in agricultural experiments and practice.

Whether this inestimable science owes its birth to the inundations of Egypt, or to more modern discoveries, is, perhaps, a question of some doubt: so far as the practice has become known and propagated under the term by which it is designated in this country, England, it is even doubtful. The West Riding of Yorkshire, we find, lays claim to its originality; though the nature of the fens in Lincolnshire and Cambridge seems to indicate an equal pretension on their parts. In either case it is obvious that the richest kind of superstratum is created by it; and

and the Agricultural Surveys, where this species of improvement has been noticed, are in unison to support this more essential conclusion.

The method recommended by Lord Hawke\* is, to bank the land, which is to be warped, against the river; sloping the banks on each side of their crown or top, at the rate of three feet to every one foot perpendicular rise. The height and breadth of the top will, of course, be regulated by the strength of the tide and depth of the water; for the object is to command the land and water at pleasure. The openings or sluices in the banks are a smaller or greater number, according with the extent of the land to be warped, and the fancy of the proprietor; but, in general, there are only two sluices; one called the *floodgate*, to admit; and the other called the *clough*, to let off the water gently. These, Lord Hawke says, are enough for ten or fifteen acres.

“When the spring tide begins to ebb,” says his Lordship, “the floodgate is opened to admit the tide, the clough having been previously shut by the weight of water

\* See Agricultural Survey of Yorkshire (W. R.) p. 164.

brought up the river by the flow of the tide. As the tide ebbs down the river, the weight or pressure of water being taken from the outside of the clough next the river, the tide-water that has been previously admitted by the floodgate opens the clough again, and discharges itself slowly but completely thro' it. The cloughs are so constructed as to let the water run off, between the ebb of the tide admitted, and the flow of the next; and to this point particular attention is paid. The floodgates are placed so high as only to let in the spring-tides when opened: they are placed above the level of the common tides."

We learn, also, from his Lordship's account that it is customary to plant willows *in front* of the banks as a protection; but not *on* the banks, because this would give the wind a sufficient power to shake and injure them.

Lands situated like those at Radcliffe, *beneath the level of the spring-tides*, appear to be the most suitable for warping; although it is the practice to warp those of other descriptions, and to warp one year in seven, which is deemed sufficient.

Lord Hawke mentions an instance of a  
field



field of *good-for-nothing* corn land, which was raised to fourteen inches of warp in three years, and then sowed with beans. From this crop he expected eight quarters. The warp consists of the mud and salts which the ebbing tide deposits; and this is more or less according to the distance from the Humber. Near Howden, says my Lord, one tide will deposit an inch of mud. “Cherry Cob Sands,” says he, “were gained from the Humber by warping; they are supposed to be four yards thick of warp at least; some of those were ploughed for twelve, fourteen, or sixteen years, before they would grow grass feeds. The land,” says he, “must be in tillage for some considerable time after warping—for six years at least. The land, if laid down to grass, and continued in grass, is not warped; for the salts in the mud would infallibly kill the grass feeds. When it is proposed to sow the land again with corn, then the land is warped; when they find the grass decline, then they warp and plough it out. As the land varies in quality, so does the time in which it will produce good grass: the land is never fallowed but in the year when it is warped.”

\* Mr. Day, of Doncaster, conceives the practice of warping in the low part of the west riding of Yorkshire, to have originated from the tides overflowing the banks of the river, and depositing a sediment which was found to produce luxuriant crops of corn. A farmer, it seems, gained light on the subject from this casualty; and obtained leave to lay a tunnel of a few inches square through the embankments of Hatfield Chace, for the purpose of warping his lands, on giving a satisfactory security in regard to the consequences of his undertaking. It is said, by this gentleman, that warping has only been spreading its beneficial influence by *artificial* practice, in this country, about twenty or twenty-five years. It is to be hoped, however, that the interesting advantages we shall be enabled to exemplify in this book, will contribute speedily to extend this very profitable acquisition towards the extermination of scarcity.

Mr. Day considers the expence of warping to be influenced greatly by the situation of the lands, and the course and distance which the warp is to be conducted. He

\* Ag. Rep. W. R. Yorkshire, p. 166.

says,

says, “ 1st, The situation of the lands is to be considered. 2dly, The quantity of land the same drains and cloughs will be sufficient to warp. 3dly, The expence of building the cloughs, cutting the drains, embanking the lands, &c. An estimate of which expence being made, then it will be necessary to know the number of acres such cloughs and drains will warp, before any estimate per acre can be made.”

It is thus clear, that the expence of warping per acre will depend greatly on the extent of land which may be overflowed by one and the same set of drains and cloughs. Mr. Day thinks that great quantities of land in the country might be warped at so small an expence as from four to eight pounds per acre ; and he states the advantages gained at various rates, from five to fifty pounds per acre ; and considers the greatest advantage to arise from warping the worst and most porous land \*.

In enumerating the advantages that accrue from warping, this gentleman says the land will bring very large crops for several years afterwards without any further manure ; and

\* Ag. Survey York. W. R. p. 168.

that warping may be easily repeated at a small expence by opening the old drains, which may serve in the interim for draining the land if it should be necessary. He recommends the culture of oats for the first crop after warping; and thinks this practice better adapted to oats, wheat, or beans, than to barley; which last is rendered too strong and coarse by the great fertility of the soil. He recommends, however, a coat of warp whenever the land is fallowed; and considers this management, above all other kinds; the cheapest, when properly applied.

Mr. Day defines *warp* to be the sediment left upon the land by flooding it with *tide* water. It seems to be the letting in water where the tide flows that is termed *warping*; letting in fresh water from a river, though by a similar operation, would be called *flooding*, and not *warping*. The benefit derived from warp appears to rest in the saline particles, and a greater deposit of sediment than can be generally obtained from fresh water floodings. He recommends June, July, and August, as the best months for warping; because, at this season the soil is in its driest state, and of course the most susceptible of those impregnations and acquisitions

quisitions which are received in the acts of absorption and adhesion. He considers wet seasons the least proper for warping ; because the redundancy of fresh water, which becomes mixed with the muddy tide must necessarily weaken the saturation, and render it less capable of depositing sediment. Land thus manured is deemed to be the best for potatoes, and far the most productive.

The depth of the water to be used for warping, will vary according to the surface of the soil ; nor is it material that it should be always at the same height, although it is well to retain a depth of three or four feet where the situation and embankments will admit of it. Mr. Day attributes the first experiment in warping to Mr. Richard Jennings, of Armin near Howden, about fifty years ago. It was next attempted, he says, by a Mr. Farham, steward to a Mr. Twisleton of Rawcliffe ; and by a Mr. Mould, of Potter Grange, about forty years ago ; since when it has been gaining ground in practice. I merely mention these particulars as a reference to claims for the honour of this useful discovery, without any design to change the ground on which I find the various pretensions.

The Secretary to the Board of Agriculture has paid minute attention to the subject of warping in the County of Lincoln; and speaks of it as one of the most singular and interesting improvements in husbandry which he has any where heard of\*.

“The water of the tides that come up the Trent, Ouse, Dun, and other rivers,” says he, “which empty themselves into the great estuary of the Humber, is muddy to an excess; in so much, that in summer if a cylindrical glass, twelve or fifteen inches long, be filled with it, it will presently deposit an inch, and sometimes more, of what is called *warp*. † Where it comes from, is a dispute.

\* See Ag. Surv. of Lincoln, p. 216.

† A similar question suggested itself to my mind a year or two ago, on observing the accumulation of silt in the Ouse, and other rivers of the fen countries, since the period of the Roman possessions there, as represented in the loose existing documents concerning drainage. It appears to me to be a matter of importance to the engineering of that country, to ascertain the precise points of deep water outfall into the North Sea; and to trace, as far as practicable, the exact tendency of the *undertow* channel, even to the farthest extent of soundings: for it would seem to be a fruitless operation to repeat a system of error, which drains one man's land to drown another's; and which will for ever be the case while a  
mere

dispute. The Humber, at its mouth, is clear water; and no floods in the countries washed by the warp rivers bring it, but, on the contrary, do much mischief by spoiling the warp.

In

mere surface-view of the subject is palmed upon the parties concerned, for professional knowledge. An investigation of the *reports* on this particular, when made by men of science, will easily discover the *fortunate* man to whose *popular* opinion I allude; I trust the very honourable profession of engineers, to several of whom I am now personally known, will not think me so illiberal as to hint at any *general* reflection. To return however to the *point*, I have often been persuaded that the extreme degree of siltage which these rivers admit, owes its existence to a cause so far back, that it must for ever hinge on conjecture. The sections of the land on the coast of France and England, as well as the intermediate soundings, and the action of the tides upon the part called the *Rip Raps*, (from the motion which the meeting of the waters occasions), indicate very strongly, I think, that the period once existed when the countries of France and England formed one land; and the channel itself was no more than a river. However surprising it may be thought, at first view, that such an astonishing convulsion of nature should have happened, as that which must have been required to rend and separate such a vast body of earth, and to scatter it about in the North Sea, from whence the continual friction of the tides must have been gradually shifting it about for many thousand years, it is  
not

In the very driest seasons, and longest droughts, it is best and most plentiful. The improvement is perfectly simple, and consists in nothing more than letting in the tide

not wholly improbable or without corroborating examples which are better known to us.

The remains of the *Godwin Sands* are a discernable subject; and records afford a more distant knowledge of their history.

*Chartley-moor*, in Lancashire, according to *Leland*, Vol. VII. p. 49. (See *Lancaster Surv.* p. 105.) was the subject of an extraordinary convulsion in former days; and the historical account informs us, that not only a part of that tract of land was precipitated into the river Mersey, but that it was also distributed along the shores of Wales, the Isle of Man, and even some of it into Ireland. A similar breach, on this small scale of extraordinary events, happened many years ago at Daggenham, upon the river Thames; and there are many other instances in Great Britain.

In the year 1782, I was myself on board a vessel then cruising along the American coast, at a place called *Harvey's Quarters*, not far from the mouth of Little Egg-harbour river; and, in viewing several wrecks which were visible at low water, a Mr. Willis, then on board, assured me, that, within thirty years before that time, he had purchased millions of Mr. Harvey's negroes, who then resided at that estate, which was a considerable tract of land: at present the shoals formed by its remains extend far from the shores of the main land.

I think



tide at high water, to deposit the warp, and permitting it to run off again as the tide falls; this is the aim and effect. But to render it efficacious, the water must be at command, to keep it out and let it in at pleasure; so that there must not only be a cut or canal made to join the river, but a sluice at the mouth to open or shut as wanted; and that the water may be of a proper depth on the

I think whoever has been among the Bahama Islands will agree with me, that there are visible traces there of a country, which has been formerly united with the American continent.

The traditions of the Seminola Indians assert, that it is not many generations back that their ancestors crossed the Gulph of Mexico, in canoes, to the Island of Cuba. This seems to have been equally probable in respect to the Grand Bank of Bahama, which seems not to be less practicable; and there are also very probable proofs, even yet to be seen, which induce a rational supposition, that the whole West-India Islands formed a part of the western terra firma. To men of science I dare yet be farther bold by putting the question, whether, in considering the current of the Gulph-stream, and the visible islands, rocks, and soundings, which pourtray the line of terrene affinity across the Atlantic Ocean, from the banks of Newfoundland to the Canarian coasts of Africa, still more important philosophical questions are not suggested?

W. T.

land

land to be warped, and also prevented flowing over contiguous lands, whether cultivated or not, banks are raised around the fields to be warped, from three or four to six or seven feet high, according to circumstances. Thus, if the tract is large, the canal which takes the water, and which, as in irrigation, might be called the grand *carrier*, may be made several miles long; it has been tried as far as *four*, so as to warp the lands on each side the whole way; and lateral cuts may be made in any direction for the same purpose, observing, however, that the effect lessens as you recede from the river; that is, it demands longer time to deposit warp enough. But the effect is very different from that of *irrigation*\*; for it is not the water that works the effect, but the mud, so that in floods the business ceases, and also in winter; and it is not to manure the soil, but to create it†.

What the land is, intended to be warped, is not of the smallest consequence; a bog, clay, sand, peat, or a barn floor—all one; as

\* I distinguish this *simple* irrigation. W. T.

† I should call ploughing, for the purpose of burying or turning in a sediment thus deposited, a manuring by means of compound irrigation. W. T.

the

the warp raises it in one summer from six to sixteen inches thick ; and in hollows, or low places, two, three, or four feet, so as to leave the whole piece level.

Thus a soil of any depth you please is formed, which consists of mud of a vast fertility, though containing not much besides sand ; but a sand unique.

Mr. Dalton, of Knaith, sent some to an eminent chemist ; whose report was, that it contains mucilage, and a very minute portion of saline matter ; a considerable one of calcareous earth ; the residue is mica and sand ; the latter in far the largest quantity ; both in very fine particles. Here is no mention of any thing argillaceous ; but from examining in the fields much warp, I am clear there must be clay in the same, from its caking in small clods, and from its cleansing cloth of grease almost like fuller's earth.

A considerable warp-farmer told me, that the stiffer warp was the best ; but in general it has the appearance of sand, and all glitters with micaceous particles.

So much, in general, as to the effect : the culture, crops, &c. are circumstances that will best appear, with others, in the following notes taken on the spot.

The

The first warping works which I viewed were at Morton Ferry, where Mr. Harrison, who shewed me them, has a large concern in a very great undertaking, no less than to warp 4620 acres of commons, by means of an act of inclosure and drainage. They are attempting to warp four hundred acres in one piece, which is to be sold to pay the expence of doing all the rest, and they have been offered 30s. an acre rent for it, when finished: a double sluice is erected to take the water from the Trent, which cost 1200l. and a double canal, cut under the idea that water should come in by one, and return by another; this apparently has created a great expence.

They have used fifteen tides over 200 acres, which has raised about six inches of warp in some places, but not uniform: and the opinion of the best informed persons is, that they must divide it into fifty-acred pieces, and do one at a time. All this may be easily corrected, and the improvement will be amazingly great. The common is worth nothing, as it has been hitherto fed.

This statement by the Secretary of the Board of Agriculture is followed by an official report and estimate concerning the premises;

premises; and by many other interesting notes. From these, I shall select such particulars as promise an advantageous result through this present medium of distribution.

The whole quantity of waste land inclosed, appears, as before stated by Mr. Young, to be 4260 acres by actual survey, 2600 acres of which is low land capable of being warped; the remaining 1660 acres high land.

The surface is a very level one, but admits of a sufficient fall for competent drainage. Two apertures of eight feet wide, and ten feet high, each, are recommended for the warping-fluices of this undertaking. The warping drains to be 18 feet wide at bottom, 26 feet at top, and 4 feet deep; and to have a foreland of 4 feet, with banks on each side of 14 feet base, 6 feet top, and 5 feet high each.

Another drain, in these works, to be 24 feet bottom, 32 feet top, and 4 feet deep, with forelands, &c. as aforesaid: this drain leads to the *outfall*. Three fluices, of 10 by 8 feet, are appropriated to the use of the three drains which discharge at this point; and

and the fluices are laid 2 feet lower than low-water mark. The following, as reported, is an

*Estimate of the Expence.*

	£.	s.	d.
Cutting the catch-water drain, 400 chains, or 3696 floors of earth, at 3s. each -	554	8	0
Cutting a main-drain, or warp- ing-drain, 258 chains, or 3746 floors, at 4s. each - -	749	1	0
Cutting a main or warping-drain, 276½ chains, or 4015 floors, at 4s. each - - -	803	0	0
Cutting a main-drain, 100 chains, or 1848 floors of earth, at 4s. per floor - / - -	369	3	0
Warping-fluice near Morton	400	0	0
Ditto, near Walkerith -	400	0	0
Outfall ditto near Ravenfleet -	600	0	0
Carried forward,	£.3875	12	0

Amount

	£.	s.	d.
Amount brought forward,	3875	12	0
Road-bridge near Morton -	150	0	0
Ditto at Swansea Bridge -	180	0	0
Two culvers under the warping- drains, at 100l. each - -	200	0	0
	<hr/>		
	4405	12	0
Contingencies, 10 per cent.	440	10	0
	<hr/>		
Total	£4846	2	0
	<hr/>		

Various valuable examples here follow on the same authority.

At Althorpe 300 acres are improving from an inferior state to 30s. per acre. At Knaith an experiment ascertains warp to be equal to dung. Similar undertakings at Amcots. At Gainborough a spot was warped to the depth of 10 inches in eight hours. When a bank breaks in warping works upon the Trent, they surround the spot with a new semi-circular bank, in order to let in the warp, which fills it up presently.

The improvements by warping, which Mr. Webster has made at Bankside, (which is within the county of York) merit particu-

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lar

lar attention. His farm contains 212 acres of land, all warped. It cost him 11l. per acre, and he would not now take 70l. for it. He thinks it worth 80l. per acre generally, and some parts worth 100l. The whole expences of his improvements did not exceed 2,500l. or 12l. per acre. A neighbour below him offers 5l. per acre for the use of his sluice and main cut to warp 300 acres ; which amounts to 1,500l. and reduces the expence of Mr. Webster's works to 1000l. Take it, however, at the highest, and say that the land cost 11l. and the improvements 12l. per acre, making 23l. and he will gain, by a sale at 70l. per acre, 47l. per acre, or 9,964l. upon the operation.

The depths warped, in this instance, in four years, were 18 inches, 2 feet,  $2\frac{1}{2}$  feet, &c. This Gentleman has warped some land which, before warping, was moor land, worth only 18d. per acre ; but it is now as good as the best: some of it would let at 5l. per acre for flax and potatoes ; and the whole at 50s. He has 20 acres that was warped 3 feet deep, between the beginning of June and end of September ; and 18 acres, part whereof is  $3\frac{1}{2}$  feet deep of warp.

This



This Gentleman has also applied warping on stubbles in autumn, by way of manuring. The crops have been very great; of potatoes, from 80 to 130 tubs per acre; each tub measuring 36 gallons, and selling at 3s. to 3s. 6d. per tub for the round kind; and at 5s. to 8s. per tub for the kidneys: this, at the present price, May, 1800, at 2d. per pound in London, would be an enormous product.

\* Twenty acres, warped by this Gentleman in 1794, could not be ploughed for oats in 1795; he therefore sowed the oats on the fresh warp, and scuffled in the seed by men drawing a scuffler, allowing nine men to a scuffle: three acres of this, measured separately, afforded 14 quarters 1 sack per acre. I very much doubt that the boasted crops of Kentuckie have exceeded this.

Mr. Webster also warped 12 acres of wheat stubble, and sowed it with oats, in April, which produced 12 quarters per acre: then wheat, 36 bushels per acre; never less than 30 bushels per acre.

Six acres of beans, says Mr. Young, produced 30 loads per acre, or 90 bushels; and one acre, measured for a wager, went 9

\* See Survey of Lincoln, p. 283.

bushels over this. These lands have produced 144 pods from one bean on four stalks; and Tartarian oats 7 feet high. One piece warped in 1793, produced oats in 1794, at the rate of 6 quarters per acre: white clover and hay seed were sown with them, mown twice the first year; the first cutting yielded 3 tons of hay per acre; the second 1 ton; and after that an immense eddish.

The great beauty of this species of improvement seems to consist, not only in the capacity for creating soil altogether, but also in the ease with which land can always be reinstated or refreshed at small expence. Flax produces on warp lands 40 to 50 stone per acre.

A sluice for warping, 5 feet high, and 7 feet wide, will warp 50 acres per annum; and perhaps 70 acres, if the land lies well, and near the river. The costs will be from 400l. to 500l.

Warped lands, at Reeveleys, has sold for 100l. per acre. Lord Beverley has six or seven sluices going, and has warped 300 acres in a year.

Twenty-four thousand pounds was, some time past, expended in making a canal from the river Trent, near Althorpe, to Thorne, &c.

&c. This is a navigable canal of 40 feet bottom, and designed for warping a vast extent of country. A branch to Crowle is laid out; and another from Thorne to the river Dun: these are for navigation; and on each side of the navigable canals are fokage drains for relieving the overflowing waters of the country, and at other times admitting tide water for the process of warping. It is proposed to make cuts of twelve miles, at right angles, for the purpose of selling warp to the country, and for delivering through sluices on either side, as occasion requires. The price proposed is from 4 to 5 pounds per acre; and provision against siltage of the works, &c. is made so that the fokage drains can be scoured or supplied by means of sluices from the navigable canal.

\* Mr. Nicholson, of Rawcliffe, (which is also in Yorkshire) takes the levels first, and builds a sluice. If he has to convey the warp the distance of a quarter or half a mile, sixty acres may be done the first year; but the drier the season the better. The clough or sluice, &c. is 8 feet wide, and 5 or 6 feet high. Drains 14 feet at bottom, and as

\* See Agricul. Survey of Lincoln, p. 284.

much more at top. Banks are 4 to 8 feet high. He begins at Lady-day, and continues till Martinmas. Three inches of warp will produce great crops, and they will be as good at six inches as at six feet. Warp is cold, and, if deep, takes time: a dry year is the best. Crops ought to be, beans 20 loads; wheat 10 or 12 loads; oats 10 quarters; never barley: after six years, potatoes and good flax. Mr. Nicholson makes it worth 40 or 50l. per acre. By keeping up the sluices and drains, land can always be refreshed at any time. Crops of flax on this kind of land have been sold at 10l. per acre standing; it is afterwards sown in rape. These lands Mr. Nicholson had warped to a level, on a slope gradually accumulating warp from the depth of two feet to six inches.

At Snaith sand land for the plough has sold at 100l. per acre.

Warp is said to leave an eighth of an inch every tide: hence we have a datum for regular calculation; and, if we take away the sediment which is deposited, for the purpose of manuring the higher lands, we may easily estimate the time when the tides will re-instate

inflate the warp, and add so much clear gain to the quality of the upland estate.

Warp is said to be left on the premises in distinct and separate flakes, not in one consolidated mass; the water should be made to run perfectly off, that the warp may incrust; and this cannot be the case if much water is suffered to remain in the drains: thus, where there is only one sluice, it can only be used every other tide.

On the sea coast, from Wisbeach to Boston, there is much silt or warp; and some experiments have been tried by Major Cartwright and others, which ought, from their favourable result, to stimulate farmers to carting or boating this kind of manure to their upland farms, where they have not the means of irrigating in the usual method, and can procure the warp within a practicable distance.

Much, in this respect, must nevertheless depend on the combination of circumstances which the landlord facilitates by interweaving his own interest in the web of his cultivator's prosperity.

To what extent this inestimable improvement will be extended in the course of a few years, it is not easy to determine. An ex-

tensive field is left open for it in the fens of Lincolnshire, the Bedford levels, and the adjacent country; and it rests with land proprietors in those parts to benefit themselves, by enabling others to better their condition in the enterprize. If this is not done, while the accepted day is present, we may venture to predict that more favoured countries will become competitors for agricultural superiority; for there can be no doubt that the enterprizing genius of the present generation will anticipate the future advantages which British experiments have brought to light in countries whose fertility and expanse is by no means inferior to the warpings of the Humber, or the fructifying inundations of the recently explored territories of Egypt.

PUTRID WATER FROM THE STEEPING OF  
FLAX, HEMP, &c.

*(Taken from the 26th §. XV. Chapter, proposed Rep. from the Board of Agriculture.) 1795.*

It is stated in a very valuable Report laid before the Board\*, that the land on which flax was spread for dying, after being steeped in water, being greatly improved thereby, coarse and sour pasture being changed into the best sort of grasses, and into sweet herbage, Mr. Billingsly was thence induced to apply it to pasture land by means of carts, similar to those used near London for watering the roads. The effect was astonishing, and advanced the land in value from 10l. to 50l. per acre. This liquid, he supposes, is much superior to animal urine; and it is earnestly recommended to the attention of those who cultivate hemp or flax.

In Lincolnshire, where this branch of husbandry has been much attended to, they

\* Somerset Report.

find the sediment of the pits, in which flax or hemp have been steeped, a very valuable manure; and, considering these circumstances, it would appear that an idea commonly circulated, that flax and hemp ought not to be cultivated in this country, because they are exhausting crops, and return nothing to the soil, is not perfectly well founded. It has not yet been ascertained to what extent manure from an acre of flax can be obtained, but it is probably considerable.

The circumstance above alluded to naturally leads to the following observations :

1. It is well known that flax will grow in almost any part of the country, however elevated. In consequence of the rapidity with which it grows, and the short time necessary for its remaining in the ground, it is hardly ever injured by frost. If, therefore, any quantity of flax were raised in the higher parts of our mountainous districts, and was kept in ponds or reservoirs of water there, the water might thus be converted into a useful manure; and irrigating the land below might convert it into excellent pasture.

2. The second observation is, that improving water as a manure has been much less attended to than it probably deserves.

To



To make it fit for that purpose, nothing more is necessary than to render it putrid. From its being in a liquid state, it seems to be better adapted for being brought into a putrescent state than earth, and other substances of a more compact and closer nature. If any chemist could discover a mode of quickly rendering a considerable quantity of water putrid, at a small expence, he will probably do more for the improvement of agriculture, than could possibly be effected by almost any other discovery.

The most likely mode is to collect it into pools, render it stagnant, and put green vegetable substances in it: this will produce putridity in the space of a few days.

To the above account the following is subjoined: putrid water, it would appear, must possess the singular property of extirpating that part of the grameneous tribe which are adverse to the purposes of the grazier and farmer, or of changing (as here stated) the coarse and four grasses into that sweet herbage agreeable to his wishes. This quality of water will certainly be worth attending to. In Devonshire water is meliorated by lime in ponds, there known under the name of *presidents*; which are ponds enriched by the drain

drain of an adjoining *linhay*, or yard, with the addition of a bag of lime at different times.

The author of the present work begs leave to add, that he saw in 1790, at a villa belonging to William Alexander, Esq. near Richmond, in Virginia, a pool constructed in the center of a new garden, in a poor sandy soil, into which the water was conveyed by pipes: these pipes communicated to a pump erected in a house at the end of the garden, wherein all vegetables gathered for the table were prepared by the gardener, who was a Frenchman. A cistern, with holes in the bottom, was placed beneath the spout of the pump, so that when the vegetables were put into it to be washed by pumping the water, the foul water and filth was immediately conducted into the putrescent reservoir in the center, from whence the garden was watered. On enquiring of the gardener why he did not distribute the pure water immediately from the pump? He answered, that no water was fit for a garden until it had been exposed to the sun and to the effects of putrefaction. Hence it may be supposed that this practice is common in some parts of France.

IRRIGATION IN THE DISTRICT OF WILT-  
SHIRE, AS COMMUNICATED TO THE  
BOARD OF AGRICULTURE IN THE WILT-  
SHIRE REPORT.

There is perhaps no part of this kingdom where the system of watering meadows is so well understood, and carried to so great perfection, as in this district. This, which is so justly called, *by Mr. Kent*, “the greatest and most valuable of all improvements,” was generally introduced into this district in the latter end of the last and the beginning of this century. Many of the most valuable and best formed meadows, particularly in the *Wyley Bourn*, were made under the directions of one farmer Baverstock, of Stockton, between the year 1700, and 1705. And at present there is scarcely a river or brook in the district that is not applied in some way or other to this purpose.

An imperfect scheme of watering had, undoubtedly been practised before that period. Perhaps, indeed, its introduction into this district

district is almost co-eval with that of folding sheep, with which it is intimately connected: but the *regular mode*, in which both systems are now conducted, is certainly not very ancient. Many old farmers, who have died within the memory of man, remembered when neither of the systems was conducted on any regular plan.

### *The Theory of Water-meadows.*

The idea of watering meadows, so far as it relates to bringing the water upon the land, was taken from nature. It must have been always observed, that winter-floods produced fertility, provided the water did not remain *too long* on the land.

The idea of taking the water *off* the land *at will*, and bringing it *on again at will*, is the effect of art; and the knowledge of the proper time to do this, is the effect of observation.

A water-meadow is a *hot-bed* for grass. In what manner water acts upon the land, so as to produce a premature vegetation, before

before natural vegetation begins, is a philosophical problem, which it is not a farmer's province to solve.—It was sufficient for him to know that the fact was so. Observation on the effects of water, so brought on, soon shewed him at what period its good effects ceased, and when it began to do mischief. This observation, therefore, regulated the time of keeping the water on the land; and as this period was different on different kinds of land, and at different seasons of the year, it became necessary that they should have such a command of water, as to take it off immediately as soon as they found the state of the land required it. This, by degrees, produced that regular disposition of the water-carriages, and water-drains, which in a well laid out meadow, bring on and carry off the water as systematically as the arteries and veins do the blood in the human body.

As water-meadows are totally unknown in many parts of the kingdom, and but very partially known in others, it may not be thought improper, in the agricultural account of South Wiltshire, to speak a little more fully on their nature and properties. If it should tend to excite the same improvement

ment in other counties, one of the great objects of the Board of Agriculture will be attained.

*The Nature and Properties of Water-meadows.*

It has been already premised, that the principal contrivance of a water-meadow is the power of bringing on and carrying off the water at pleasure. And provided this great object can be accomplished, it is not material what the shape of a water-meadow is, or that the disposition of the trenches, technically *the works of the meadows*, should be uniform.

But as very little land can be entirely commanded by water, unless its inequalities are reduced by manual labour, it has been found convenient to adopt two different kinds of water-meadows, one for land lying on declivities, and which must in general be watered from springs or small brooks; and the other for low land rivers, to be watered from those rivers.

The

The first kind is called in Wiltshire, “*catch-work meadows* ;” and the latter, “*flowing meadows*.” The latter are by far the most general in this district.

It is impossible to give any fully-intelligible written description of the mode of making these meadows : this operation must be seen, to be properly understood.

### *Catch-work Meadows described.*

But to elucidate the distinction between the two kinds of meadows, and to give some idea what are the situations in which they may be introduced, it may be necessary to remark, that the catch-work meadows\* are made by turning a spring, or small stream, along the side of a hill, and thereby watering the land between the new cut, or, as it is provincially called, the main-carriage, and the original water-course, which now

\* The “catch-work meadows,” are the kind that are so common on the sides of the hills in Devonshire ; and are partly described by plates under the Gloucestershire head.

becomes the main-drain. This is sometimes done in particular instances, merely by making the main-cut level, and stopping it at the end; so that when it is full, the water may run out at the side, and flood the land below it. But as the water would soon cease to run *equally* for any great length, and would wash the land out in gutters, it has been found necessary to cut small parallel trenches, or carriages, at distances of twenty or thirty feet, to catch the water again; and each of these being likewise stopped at its end, lets the water over its side, and distributes it until it is caught by the next, and so on over all the intermediate beds to the main-drain at the bottom of the meadow; which receives the water, and carries it on to water another meadow below; or, if it can be so contrived, another part of the same meadow on a lower level.

To draw the water out of these parallel trenches, or carriages, and lay the intermediate beds dry, a narrow deep drain crosses them at right angles, at about every nine or ten poles length, and leads from the main-carriage at top, to the main-drain at the bottom of the meadow.

When



When this meadow is to be watered, the ends of the carriages adjoining the cross-drains, are stopt with turf dug on the spot, and the water is thrown over as much of the meadow as it will cover well at a time, which the watermen call a *pitch of work*; and when it is necessary to lay this pitch dry, they take out the turves, and let the water into the drains, and proceed to water another pitch.

This kind of water-meadows is seldom expensive: the stream of water being usually small and manageable, few hatches are necessary; and, the lands lying on a declivity, much less manual labour is required to throw the water over it regularly, and particularly to *get it off again*, than in the flowing meadows. The expence of making such a meadow is usually from three to five pounds per acre; the improvement frequently from fifteen shillings an acre, to at least forty, per annum.

The annual expence of keeping up the works, and watering the meadow, which is usually done by the acre, seldom so high as 7s. 6d. per acre.

*Flowing-meadows described.*

The other kind of water-meadows, *viz.* those usually called *flowing-meadows*, require much more labour and system in their formation. The land applicable to this purpose being frequently a flat morass, the first object to be considered is, how the water is to be *got off* when once brought on; and in such situations this can seldom be done without throwing up the land in high ridges, with deep drains between them. A main-carriage being then taken out of the river at a higher level, so as to command the tops of these ridges, the water is carried by small trenches or carriages along the top of each ridge, and by means of moveable stops of earth is thrown over on each side, and received in the drain below, from whence it is collected into a main-drain, and carried on to water other meadows, or other parts of the same meadow below. One tier of these ridges being usually watered at once, is called "*a pitch of work*;" and it is customary to make the ridges thirty or forty feet wide, or,

or, if the water is abundant, perhaps sixty feet, and nine or ten poles in length, or larger, according to the strength and plenty of water.

It is obvious, from this description, that as the water in this kind of meadow is not used again and again in *one pitch*, as in the catch-meadows, that this method is only applicable to large streams, or to valleys subject to floods; and as these ridges must be formed by manual labour, the expence of this kind of meadow must necessarily exceed the more simple method first described: and the hatches that are necessary to manage and temper the water, or rivers, must be much more expensive than those on small brooks.

The expence, therefore, of the first making such a meadow as this is, will be from twelve pounds to twenty pounds per acre, according to the difficulty of the ground, and the quantity of hatch-work required: but the improvement in the value of the land by this operation is astonishing.

The abstract value of a good meadow of this kind may fairly be called three pounds per annum per acre; but its value, when taken as part of a farm, and particularly of a sheep-breeding farm, is almost beyond computation;

and when such meadow is once made, it may be said to be made for ever, the whole expence of keeping up the works, and watering it frequently, not exceeding five shillings per acre yearly; and the expence of the hatches, if well done at first, being a trifle for a number of years afterwards.

*Supposed Quantity of Water-meadow in  
this District.*

The number of acres of land in this district, under this kind of management, has been computed, and with a tolerable degree of accuracy, to be between fifteen and twenty thousand acres.

Indeed it has been found so very beneficial, that very few spots of land, capable of being watered, remain otherwise, unless where some water-mill stands in the way, or where some person who has the command of water above, refuses to let it be taken out of its natural course to water the lands below.

Some new meadows might be made, and very great and beneficial alterations made in  
the

the old ones, if some plan could be adopted to get the command of water where necessary for this purpose ; and particularly in the case of water-mills. A remedy for this will be hereafter proposed.

*Water-meadows do not make a Country  
unhealthy.*

It has been alledged, by those who know very little of water-meadows, that they render the country unwholesome by making the water stagnant : daily observation proves the fact to be otherwise in Wiltshire—and the reason is obvious. It has been already said, that a water-meadow is a *hot-bed for grass* ; the action of the water on the land excites a *fermentation* ; that fermentation would certainly in time end in a *putrefaction* : but the moment putrefaction begins, vegetation ends. Every farmer knows the commencement of this putrefaction, by the scum the water leaves on the land ; and if the water is not then instantly taken off, the grass will rot, and his meadow be spoiled for the season.

The very principle of water-meadows will not permit water to be stagnant in a water-mead country; it must be always kept in action to be of any service: besides, many of the best water-meadows were, in their original state, a stagnant unwholesome morass.

The draining such land, and making it so firm, that the water may be taken off at will, must contribute to the healthiness of the country, instead of injuring it.

### *Great Advantages from Water-meadows.*

It is frequently asked, how it comes to pass that although water-meadows are so useful as to be almost indispensable in South Wiltshire, yet in other counties, where they are not known, the want of them is not felt; nay, that there are, even in this district, many parishes who have none, and even breed lambs without them?

To this it is answered, that the fair question is not, "How do other countries do without them?" but, "How could the farmers of this district, who are happy enough to have water-meadows, pursue their present  
present

present system, of sheep-breeding if those meadows were taken away?" A system which is said to be more profitable to themselves, their landlords, and the community at large, than any other that could be substituted in its room; and perhaps this question cannot be answered better, than by exhibiting the contrast between those who have water-meadows, and those who have none, in the same district.

Every farmer who keeps a flock of sheep, and particularly a breeding flock, in so cold and late-springing a district as South Wilts, knows and feels the consequences of the month of April. "That month, between hay and grafs, in which he who has not water-meadows for his ewes and lambs, frequently has nothing!" The ewes will bring a very good lamb with hay only; perhaps a few turnips are preserved for the lambs, which in a very favourable season may last them through March; but if they are then obliged to go to hay again, the ewes shrink their milk, the lambs "pitch and get stunted," and the best summer food will not recover them. To prevent this, recourse is had to feeding the grafs of those dry meadows that are intended for hay, the young

young clover, and frequently the young wheat; in fact, every thing that is green. And who will pretend to estimate the loss that a farmer suffers by this expedient:

The ray grafs on the exposed parts of this district is seldom "a bite" for the sheep till near May-day. If the season should permit any turnips to be kept till that time, which can seldom be depended on, they are not only of little nourishment to the stock, but they exhaust the land so as to prejudice the succeeding crop. And it ought to be remarked by the way, that in many parts of this district the soil is not at all favourable to the production of turnips. It therefore necessarily follows, that a farmer, under these circumstances, has no certain resource to support his stock during these months, but hay; and even in that he is sometimes disappointed, by having been obliged in the preceding spring to feed all the land which he had laid up for a hay crop: he is then obliged to buy hay, and that frequently at the distance of many miles: and, to add to his distress at this critical time, his young ewes are then brought home from wintering to be kept nearly a month on hay alone.

In



In this month, which so often ruins the crops, and exhausts the pockets of those sheep-breeding farmers who have no water meadows, the water-mead farmers may be truly said to be "in clover." They train up their dry meadows early, so as almost to insure a crop of hay; they get their turnips fed off in time to sow barley, and have the vast advantage of a rich fold to manure it. They save a month's hay, and have no occasion to touch their field grass till there is a good bite for their sheep; and their lambs are as forward at May-day, as those of their less lucky neighbours are at Midsummer: and, after all, they are almost certain of a crop of hay on their water meadows, let their season be what it will.

### *Management of Water Meadows.*

The management of water meadows is in the following way:

As soon as the after grass is eaten off as bare as can be, the manager of the mead, provincially the drowner, begins cleaning out the main drain, then the main carriage, and

and then proceeds to “right up the works;” that is, to make good all the water carriages that the cattle have trodden down, and open all the drains they may have trodden in, so as to have one tier or pitch of work ready for drowning, and which is then put under water, if water is plenty enough, during the time the drowner is righting up the next pitch. In the flowing meadows this work is, or ought to be, done early enough in the autumn, to have the whole mead ready to catch, if possible, the first floods after Michaelmas, the water being then “thick and good;” being the first washing of the arable lands on the sides of the chalk hills, as well as of the dirt from the roads, &c. &c.

The length of this autumn watering cannot always be determined, as it depends on situations and circumstances; but if water can be commanded in plenty, the rule is to give it a “thorough good foaking” at first, perhaps a fortnight or three weeks, with a dry interval of a day or two; and sometimes two fortnights, with a dry interval of a week; and then the works are made as dry as possible, to encourage the growth of the grafs. This first foaking is to make the land sink and pitch close together; a circumstance

stance of great consequence, not only to the quantity, but to the quality, of the grafs, and particularly to encourage the shooting of the new roots which the grafs is continually forming, to support the forced growth above.

While the grafs grows freely, a fresh watering is not wanted; but as soon as it flags, the watering may be repeated for a few days at a time, whenever there is an opportunity of getting water, always keeping this fundamental rule in view, to make the meadows as dry as possible between every watering; and to stop the water the moment the appearance of any scum on the land, shews that it has already had water enough.

Some meadows that will bear the water three weeks in October, November, or December, will perhaps not bear it a week in February or March; and sometimes scarcely two days in April or May.

In the catch meadows watered by springs, the great object is to keep the works of them as dry as possible between the intervals of watering; and as such situations are seldom affected by floods, and generally have too little water, care is necessary to make the most of the water by catching and rousing it

as often as possible ; and as the top works of every tier or pitch will be liable to get more of the water than those lower down, care should be taken to give the latter a longer time, so as to make them as equal as possible.

*Custom of feeding Meadows with Sheep.*

It has already been said that the great object, in this district, of an early crop of water-meadow grass, is to enable the farmer to breed early lambs.

As soon as the lambs are able to travel with the ewes, perhaps about the middle of March, they begin to feed the water meadows. Care is or ought to be taken to make the meadows as dry as possible for some days before the sheep are let in.

The grass is hurdled out daily in portions, according to what the number of sheep can eat in a day, to prevent their trampling the rest ; at the same time leaving a few open spaces in the hurdles for the lambs to get through, and feed forward in the fresh grass.

One

One acre of good grafs will be fufficient for five hundred couples for a day.

On account of the quicknefs of this grafs, it is not unufual to allow the ewes and lambs to go into it with empty bellies, nor before the dew is off in a morning.

The customary hours of feeding are from ten or eleven o'clock in the morning to about four or five in the evening, when the fheep are driven to fold; the fold being generally at that time of the year on the barley fallow: and the great object is to have water-mead grafs fufficient for the ewes and lambs till the barley fowing is ended.

### *Meadows laid up for Hay.*

As foon as this firft crop of grafs is eaten off by the ewes and lambs, the water is immediately thrown over the meadows, (at this time of the year two or three days over each pitch is generally fufficient) and it is then made perfectly dry, and laid up for a hay crop. Six weeks are ufually fufficient for the growth of the crop; it feldom requires eight: and there have been instances of great crops being produced in five.

*Nature*

*Nature of Water-meadow Hay.*

The hay of water meadows being frequently large and coarse in its nature, it is necessary to cut it young ; and if made well, it then becomes of a peculiarly nourishing, milky quality, either for ewes or dairy cows.

The water meadows are laid up for a second crop in some instances, but this is only usual when hay is scarce ; not that it is supposed to hurt the land, but the hay is of that herbaceous, soft nature, and takes so long time in drying, that it is seldom well made. It is usually of much greater value to be fed with dairy cows : and for that purpose a flash of after grass, so early and so rank, will be precisely of the same comparative service to the dairy, as the spring feed has been described to be for ewes and lambs.

The cows remain in the meadows till the drowner begins to prepare for the winter watering.

*Water Meadows safe for Sheep in Spring,  
but will rot them in Autumn.*

Water meadows are reckoned to be perfectly safe for sheep in the spring, even upon land that would rot sheep if it was not watered; but in the autumn the best water meadows are supposed to be dangerous. This is at present an inexplicability in the operations of nature, and a discovery of the reason might lead perhaps, in some measure, to a discovery of the causes of the rot in sheep \*. But the circumstance itself is rather an advantage than a disadvantage to this district, as it obliges the farmers to keep a few dairy cows to feed the water meadows in autumn, and to provide artificial grasses, or other green crops for their sheep, during that period.

\* See Paper, by the author of this book, on the disorder in animals, termed Staggers, published in Dr. Anderson's Agricultural Recreations, about June or July, 1799.

*Proper Soil for Water Meadows.*

From what has been so repeatedly urged on the necessity of making water meadows dry, as well as wet, every reader must have inferred the advantage of having them, if possible, on a warm absorbent bottom \*.

The bottom or sub-soil of a water mead is of much more consequence than the quality or the depth of the top soil. Not but that the land on peaty or clay bottoms may be considerably improved by watering; and there are many good water meadows on such soils, but they are not so desirable, on account of the difficulty of draining the water

\* There is a striking proof of the truth of this remark in the water meadows near Hungerford, and particularly at Standen. Although they are laid out in no regular plan, and in many instances there are no drains to empty the water carriages, yet the gravel bottom is so very absorbent, that the water will soak out in a few hours, and the meadows be left as dry as if they were watered on the most systematic plan: few meadows in the country produce better crops, either of spring feed or of hay.

out



out of them, and making them firm enough to bear treading.

A loose gravel, or what perhaps is still better, a bed of broken flints, with little or no intermixture of earth, whenever it can be obtained, is the most desirable bottom.

On many of the best water meadows in this district, where the bottom is a warm, absorbent gravel, or rather a bed of broken flints, the soil is not quite six inches deep; and that depth is quite sufficient, in those seasons when water is plenty, as the grass will root in the warm gravel in preference to the best top soil whatever; and such meadows always produce the earliest grass in the spring. Nor is it so very material of what kind of grasses the herbage is composed when the meadow is made: that kind will always predominate which agrees best with the soil and the water, provided the supply of water is regular and constant every winter; in other words, that kind will predominate which will bear wet and dry, and some of the worst grasses, in their native state, will become the best when made succulent by plenty of water.

*Use of Water Meadows.*

The water meadows of Wiltshire and the neighbouring counties are a branch of husbandry that can never be too much recommended.

In speaking of water meadows, it has been objected that they are local; and that there are many parts of the kingdom in which they neither can be made, nor are they necessary if they could be made.

There are undoubtedly, says the Communication to the Board, many parts of the kingdom in which water meadows cannot be made\* ; but nobody will deny but that there are thousands of situations where they could be made, in which they have never been tried. And as for their use, it may be strongly suspected, that those who deny it have never been in Wiltshire in the month of April. Let those who call it in question point out a

\* This book, however, goes to prove, that by means of art and machinery water meadows can be made any where! W. T.

substitute on which the farmer can, with equal certainty, depend for the sustenance of his flock in that trying month.

Whatever may be the earliness of the season, with respect to the springing of either ray grafs or meadow grafs, water meadows will be a month before either.

And notwithstanding the great advantages that have been derived from the introduction of green winter crops, such as turnips, rape, cabbages, &c. (advantages to this kingdom almost beyond estimate) yet this may be laid down as a certain maxim, that whether the winter be hard or mild—whether the spring be late or early, nature will always have, in this climate, an “*interregnum*” between the end of one year’s food and the beginning of another. The same temperature of the air in the spring, which brings on the grafs, will occasion all green winter crops to run to seed, and not only to loose their own nourishing quality, but to exhaust the land on which they grow.

A moment’s reflection will convince every man, that nature must unavoidably and constantly leave this chasm in the year’s food. Winter, though driven into a small com-

pafs, is ftill winter, and art alone can expunge it from the Kalendar.

Hot-houfes and hot-beds have, in a great meafure, done this for the gardener. Water meadows, which are hot-beds for grafs, will as effectually do it for the farmer. How neceffary is it, therefore, to impreff the value of this branch of husbandry on the minds of all the land-owners in the kingdom.

It is not only the moft valuable, but the moft permanent, of all improvements in husbandry. It not only improves the land on which it is made, but makes all the adjoining land better by its produce; and it differs in one very material refpect from all other improvements that a landlord can make for a tenant; that is to fay, that time will even make it better, and that the careleffnefs of a tenant cannot make it much worfe.

Before I take leave of the very interefting examples of irrigation which this county affords, I think it proper to notice a very particular objection to the extenfion of fuch canals as may be neceffary to a complete watering; which, while it arifes from the fear of deftroying the fources of agricultural irrigation on the one hand, fhould operate  
with

with double force on the other, in favour of that combination of interests, which nothing less than a system of national irrigation can give.

In page 156 of the Wiltshire Report, it is stated that only one canal, viz. the Thames and Severn navigation, passes through that county. That several others have been proposed, and that some are yet contemplated; “but the fear that canals will deprive the water meadows of water, makes many of the landholders averse to them.” If Government would step forward with the primary means of general supply which is contemplated in my design, this, with a thousand other objections which create an endless expence, and waste much of the national time in Parliament, would for ever after vanish; and plenty and conveniency would be everywhere so prevalent, that the affections of the community might harmonize in superabundance; and the disquiet of party contests become lost in the midst of profusion.

# IRRIGATION OF THE COUNTY OF WORCESTER.

The great example of irrigation which comprises the whole system of this county, is said to exist in the hands of one single family. I shall therefore content myself with the account of it which has been transmitted to the Surveyor of that county, and by him to the Board of Agriculture.

The plan of watering the lands in this neighbourhood, belonging to the Foley family, is shortly as follows :

It is, in the first place, necessary to observe, that all the mills on the brook, or stream of water, as soon as it enters on their property, until it unites with the river Stour, for near three miles, belong to them ; of course they have the control of the water. At the upper end of the stream are three or four water courses, made for several miles upon a level to the different farms that are watered ; and the whole stream is divided in a manner proportioned to the quantity of land each

each course is intended to water. The farms that receive this valuable acquisition are eight or nine, and the quantity of land watered upon the whole of them is between three and four hundred acres. The quality of the soil, in general, is a very light sand, and many parts of it mixed with gravel: by the division of the stream as above, each farm has its portion of water repeated from two days to a week, every three weeks throughout the year; and in order to prevent the least dispute between the tenants, respecting the distribution of the water, a person is appointed to turn it from one person's land to the next in turn, at certain stated times fixed for this purpose.

The farmer then takes to the management of it, and floods such parts of his lands as are generally prepared to receive it. There are very few of them that mow the whole of the land they water, but mow and graze it alternately, in such a manner that they use the water at all seasons of the year in their turn. A very considerable quantity of land in this neighbourhood is well situated to receive this improvement, if the stream was sufficient for the purpose, besides the number of acres already mentioned, the greater part  
of

of which was formerly a very poor arable land, and not worth more than five shillings an acre. The industrious farmers are very attentive to the use of water; all the gutters are cut for floating, with the use of a water level; and the more numerous the gutters are, the greater quantity of grafs the land produces.

In some situations, with the use of little stop gates, the gutters are cut deep enough to drain the land they are made to float: this circumstance, where the land requires it, is worthy of great attention. The whole plan of irrigation, where practised (and very few farms indeed but what will admit of it in some degree), is, beyond a doubt the first and greatest improvement, at the least expence, ever discovered.



## IRRIGATION IN DEVONSHIRE.

There are many inventions for irrigation in the county of Devon, and some of them (to the great honor and profit of proprietors) are carried into actual execution, on the encouragement of their own sole reason, without example to guide their judgment; and on a scale which exhibits a specimen to other countries, for the combination of commercial and agricultural advantages, in the items of agricultural irrigation, mill works, and canals.

Mr. Leach, a plain man, and surveyor by profession; who stepped into the then little trodden path of a Treatise upon the Science of Inland Navigation, with ideas which would have done honor to an abler pen, so early as the year 1791, reduces his observation to nearly this summary maxim, that *where water is, there may navigation be also*. I shall be bold enough, before I have done with the subject, to step one grade farther; for I dare pledge myself to shew, that  
there

there is not a tract of one mile-square in England into which canals may not be carried advantageously, if a proper national system is adopted under a rule similar to the Chinese maxim, which is said to compel the emperor himself to dig the first spade of earth out of his most favourite grounds, and to assure his people with an audible voice, that *no private pleasure shall obstruct the public good.*

But to return to Mr. Leach, he recommends an attention to combination in the following nervous and farmer-like language:

Agriculture, says he, is the most useful and ancient art of any whatsoever; and which most noble art, together with commerce, are the chief pillars and support of these kingdoms. It is the duty of every one, who has any regard to his duty, to promote and encourage these useful arts; and there is no contrivance whatsoever that will go so far to this end as the construction of inland navigation, and extending them into the interior of every part of the kingdom: a thing very possible to be done (says he) at any place where there is a river or stream of running water. For it may be affirmed as a fact, as it is confirmed to me by the clearest

est demonstration, that there is hardly one stream or river of running water in the universe, where there is sufficient water to work a common flour-mill, but it is capable of being made navigable.

In various parts of his work he dwells particularly on the agricultural advantages which are to be expected from the conveyance of manure, sea-sand, and other materials in husbandry; but though it is probable that the surveys he was engaged on in Cornwall and Devon, may have contributed to stimulate enterprise, and expedite execution: one of the most interesting instances of combined powers, in this way, seems to have resulted from casualty in the operations of James Templer, Esq.; to whom we are indebted for new and valuable lights in the science of *irrigation; by means of inland navigation.*

In the agricultural survey of the County of Devon, which was made in the year 1794; by Mr. Frazer, under directions from the Board of Agriculture, we are told that James Templer, Esq. of Stover, in the County of Devon, has, in the way of communication by canals, and in turning them to advantage by watering the land adjacent,  
introduced

introduced a *principle* which is capable of wonderful extension.

This gentleman has by management in the distribution of water, from a canal communicating with the sea at Teignmouth, united the *utile* and *dulce* with much propriety and effect; and which, at the same time that it reflects great honour on his genius, and must be productive of great personal emolument, has brought into light a principle of improvement not hitherto at all attended to; but properly considered, will shew that navigable canals may be rendered of advantage to agriculture, in a degree which is not thought of where they are confined merely to the purposes of conveying articles of commerce.

The water meadows belonging to James Templer, Esq. above mentioned, are situated in the parish of Teigngrace; and are under management which is perhaps no where excelled.

The soil in most parts of this parish is a very poor thin black mould, on a stratum of cold clay, which is exported in great quantities for the use of the potteries in the neighbourhood of Liverpool, and other parts of the kingdom, forming a very considerable branch  
of

of traffic. This circumstance induced Mr. Templer to form a navigable canal for the conveyance of this clay to Teignmouth, the port of shipping, without at first adverting to the use of such a canal for the purpose of watering the land. His taste for rural improvement soon made him perceive the advantages arising from this circumstance.

A very considerable tract of marshy land adjoining to the lower part of his canal, which did not produce above eight or ten shillings per acre, some not five, he drained and levelled. After which, by forming surface-conductors for the overplus water of the canal, and well-contrived sluices, he distributed the water of the winter floods, enriched with the slime from the higher grounds, over these marshes, now converted into verdant meadows. These distributary sluices are extremely simple and judicious in their construction. They consist of a number of trunks, placed at various distances, to each of which a plug is fitted. The trunks are placed above the level of the water necessary for navigating the canal; and when the floods fill the canal, these plugs are taken out, and the water is instantly distributed in a very beautiful manner

ner over the surface of the meadows ; and is easily and speedily stopped when it is conceived they have run long enough.

Mr. Templer has followed the same system in the upper line of his canal, and with similar success. These meadows he lets out for pasture grounds to his tenants ; and it is curious to remark the great difficulty he had to persuade them of the utility of this sort of management. He was even obliged to bribe them to pursue their own advantage, by giving a remittance of part of their rent to those who were most industrious in draining, and watching the opportunity of distributing the water in the floods : so very difficult is it to excite the generality of people to try new improvements ! They are now, however, very sensible of the advantages arising from this system, and are very glad to get an acre of meadow for 40s. and 3l. for which before they unwillingly paid 10s.

Another essential advantage produced by this canal, is the fine rich mud, mixed with rotten leaves of trees, &c. which is washed down by the rain, and deposited in the canal. This, in summer time, is dragged out with long-tined harrows, by the aid of a couple of horses or bullocks, and afterwards mixed with

with lime for the upper lands. This rich mud is a manure of itself, and he allows his tenants to take it freely for their own use.

In this manner he is accustoming his tenants to an industry which betters their own circumstances, while, without laying out any considerable expence himself, his land is so rapidly increasing in value, it is supposed it will in a few years equal the interest of the money laid out upon the canal, independent of the trade which is daily increasing. A most wonderful effect is said to be produced by laying sea sand on the meadows, which sand forms a back carriage for the bargemen who carry the clay to Teignmouth. What renders these operations more interesting, is, that these lands are in themselves naturally so barren, that it was thought impossible to improve them; and Mr. Templer was the object almost of ridicule to his neighbours.

The advantages arising from the canal, and from his experiments, not only to him but to the neighbouring country, which will be more and more benefited, are now generally confessed; and if it should be hereafter connected with any canals on the higher grounds of Dartmoor, the benefits arising

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from it will be so widely extended, as to render it a vast advantage to the public.

In the further accounts of this agricultural survey of the County of Devon, we find that the farmers southwardly from Stover, appear to be every where sensible of the advantages of Mr. Templer's improvements, and every little stream is applied more or less to the watering of their grounds. They also catch the floods on the roads from the declivity of the hills, and convert them to this purpose.

So far the account of Mr. Templer's improvements which I have collected from the survey above recited, as a striking instance of *what* may be done!—But, as I purpose to go farther, with a view of certain places where *much* may be done, I beg leave to notice a few particulars touching the Forest of Dartmoor as an example, which being chiefly the property of his Royal Highness the Prince of Wales, is in hands competent to great undertakings, where he may deem them to be designs which may benefit his country.

Mr. Frazer describes the western district of the County of Devon to be only patches in cultivation. By far the greatest part, says he, consists of undivided wastes and commons,



mons, amounting to between 2 and 300,000 acres of land, if not more than that quantity.

In the center of these wastes is situated the Forest of Dartmoor, the property of his Royal Highness the Prince of Wales.

This forest is the highest part of the district. In the north part of this forest, and the highest grounds, the soil consists of extensive tracts of a wet turf or peat of a great depth; in other parts of a light black soil or gravelly, intermixed with a yellowish or whitish clay. Declining from the forest in other parts of the district, it partakes more or less of similar qualities; chiefly light black peaty earth or gravelly. Many of the vales both on the forest, and in other parts of the district, appear very capable of improvement; and the whole, if stocked by cattle and sheep, capable of being made the source of additional wealth to the kingdom.

The mountains of Dartmoor form the grand reservoir, from whence water is plentifully distributed to all parts of the county.

The waters, which empty into St. George's Channel on the one hand, and Bristol Channel on the other, are said to rise within three quarters of a mile of each other; and their

sources are computed to be not more than between eight and nine hundred feet above the level of the sea ; and yet except some of the *tors*, this summit is higher than any other part of Dartmoor ; so that the height of this country is by no means so formidable as it appears to the eye of common observation.

Descending from this summit there is an immense extent of mountainous land, thro' which there are vallies and levels to be found, by which canals might be extended on a level for miles together.

The conclusion to be inferred from these premises is certainly founded in truth, when it is supposed that water cannot be more economically used, or to greater advantage, than in improving such tracts of waste lands as those about Dartmoor, by means of canals and ducts for the purpose of manuring and irrigating them ; and that this is practicable in various productive ways, adjusted to the circumstances of these or other particular premises, upon general principles which will apply every where, I flatter myself I shall be able to demonstrate in the ulterior relations of this book. By the means I shall propose, canals may be easily extended into all parts  
of

of this waste, and communicated thence to the sea by Mr. Templer's canal and other routes, by which lime, coals, sea sand, with other manures, &c. could be conveyed to this waste, and the granite, tin, copper, &c. with which it abounds, would form a trade in return. The result of these operations would be, that agriculture which, to the surprise of strangers, has proceeded so short a way from the sea coasts, would penetrate to the centre of Dartmoor, and the brown heath would soon become changed to a verdant green. Instead of miserable half-starved sheep, which are permitted to wander over these wilds without the fostering hand of a shepherd, regular flocks would be conducted with skill and care, and give an additional source of wealth to the community. By facilitating the carriage, even by small canals, the expence of manure would be reduced ; whereby the farmer might improve more land than he could manage otherwise, add beauty to his tenement, and value to the estate of his landlord.

In proportion to the extension of canals, the number of horses and mules employed as carriers will always be reduced ; and as provender is thereby saved in this item, pro-

vifions will become more abundant in another, by the increafe of oxen and fheep.

To ufe the words of my friend Mr. Fulton, (which it is difficult to avoid, feeing we have for feveral years thought and written with little variation from the fame expreffions, while at the diftance of three thoufand miles apart, and then without knowledge of each other)—Is it not interefting on this point to fee the difparity between land and water carriage: in Cornwall a mule ufually carries three hundred pounds weight, (and even in this way is Dartmoor faid to be manured,) while upon a fmall canal, the conftruction whereof I apprehend would not exceed three hundred pounds per mile, throughout the kingdom in nett expence, one mule will convey twenty tons with eafe: hence one mule performs the ordinary work of one hundred and thirty, and the greater part of mules and horfes might thus go to cheapen the impetus of neck-breaking pleasures, to lighten the burthens of manual labour, or the better purpofes of that ruftic implement the plough, which gives fuch wonderful effect towards the multiplication of our fpecies, and the production of domeftic plenty.

The

The invention of the steam-engine has been considered as a contrivance of the first importance to mankind ; because of its immensely increased capacity in saving animal labour, and reducing the burthensome expence of employing and feeding, as formerly, such numbers as were then necessary to give rotary motion to an infinity of machinery.

Those improvements of this engine which contribute to save coal, have been viewed as a material consideration in the mining interest ; and canals, which have reduced the expence of carriage in much greater ratio than the grades of power between man and horse, or between horse and waggon, must, with their powerful influence in irrigation, necessarily militate to cheapen the price, and multiply the supply of human comforts.

If the tradesmen of the several towns are enabled to procure heavy articles at a reduced carriage, their customers all feel the benefit of a proportionate price, which nevertheless secures equally a fair profit to the vendor. If coals are thus reduced in their carriage, or new mines become thus opened to market, the cottager is enabled to burn more of them ; and numerous blessings are the offspring of a comfortable & earth.

The same mode of reasoning applies to every species of pursuit which requires the transfer of heavy articles ; and regardless of the science of irrigation, to the aid whereof canals may be so constructed as to afford inexhaustible resources, there is no point in which they can be viewed but they exhibit inestimable advantages to the bulk of society ; because every amendment which reduces the quantity of animal labour, or which yields a greater abundance with the same manual applications, must render the accommodations of life more plentiful, cheap, and distributive.

When two persons, for example, are present at the common mart of traffic, with any quid pro quo of commerce which they incline to exchange, the barter will meet upon equal terms, and each will obtain a reasonable proportion of the surplus commodity of the other ; but, if one person has his produce upon the spot, and the other brings the article wanted a mile, the expence of that mile's carriage will necessarily reduce the quantity thereof to be given, upon the same principles of fair trading, in proportion to the cost of one mile's conveyance.

In the same way every additional mile's  
carriage

carriage must make a proportionate reduction of the quantity of the transferred articles to be delivered ; even to the prohibition of intercourse, unless the inland party submits to the impositions of necessity. Now at the same rates for animal conveyance, apart from attendance, there can be no material difference whether one hundred and thirty mules go one mile to bring each a sack of corn, or whether one mule goes one mile one hundred and thirty times over, to perform the same quantity of carriage. But if, by the construction of a canal of one mile in length, with the price of one hundred and twenty-nine mules, the remaining one is enabled to perform the same transfer, he thereby saves to the community the feeding, attendance, and equipments of one hundred and twenty-nine mules per day, and the charge for conveyance of merchandize will be proportionably lessened ; although those persons who are employed as carriers will receive the same degree of fair profit, as if no canal had been constructed, and yield to the community a multiplied result.

If we farther view the extension of inland canals, in respect to the various purposes of agricultural improvement for which they are capacitated,

capacitated, the mind must contemplate with surprise the wonderful prospect of multiplied resources which will proceed from the most sterile and moorish parts of the kingdom; and which Mr. Templer's actual improvements have demonstrated sound data, to expect. The mining countries perhaps might produce corn and flesh in sufficient quantities for their home consumption; and the balance of traffic would remain as an annual accumulation to penetrate farther into the earth, or to enrich and beautify its surface.

If the extension of canals can facilitate and cheapen the expence of manure, we may behold every little farmer in a condition to improve a greater quantity of soil; to polish the estate he possesses to the enrichment of his landlord; and to contribute additional benefits to the weal of society. The features of content would thus dispel the gloom of abject wretchedness from his brow; and he would behold that manliness of antient days in his growing offspring, which can alone contribute permanent safety and prosperity to his country.

In viewing canals as agents to agriculture, we should not forget the innumerable advantages which have resulted from the use of  
sea



sea-land, when it admits of carriage to the interior parts of the kingdom; and if the lands are supposed to receive melioration from the carbonic acid, or from any particular solid quality contained in that or the shells it is mixed with, it may merit consideration whether cross cuts are not practicable in most parts of the kingdom, which would justify an actual extension upon the sole principle of this species of husbandry, independent of other purposes. But if it is simply the saline that is required, it may prove no difficult matter to form reservoirs upon the several eminences which overtop the respective neighbourhoods, by extending pipes in the nature of water-works, as an undertaking of Government, which being properly systemized, may accommodate agriculture in the remotest parts, and form salt-water baths in the city of London, or extend them into every parish in the kingdom, and ornament the pleasure grounds of those who may prefer such, with cascades and fountains of a species which no other country exhibits.

There are some other considerations in favour of agricultural canals, which should not be omitted.

By

By land carriage it is absolutely impossible to perform a sufficient transfer of manure, to gain any considerable advantage of time and quantity during the continuance of a season ; but by agricultural canals the quantity may be multiplied, the price reduced, and the season extended to a spacious tract of farm.

This increase of improvement will remunerate its accumulation with manifold force. The quantity of articles carried upon a canal will enable conveyance at less expence ; or the surplus monies may be applied to the distribution of more minute blessings, into the smaller arteries of irrigation.

To facilitate and expedite these great ends, it would be a desirable attainment to effect some more cheap and simple method of raising a supply of water equal to the undertaking, from the lower resources of lakes, rivers, and the tides ; for the construction, wear, and tear of the steam engine, and other expensive machinery, together with their contingent charges, are a considerable drawback on the advantages of an agricultural use of water. I have endeavoured to contribute my mite to this kind of improvement in the following pages : I submit them  
to

to the public, in hopes that they may stimulate some more able genius to add his thoughts on this interesting particular.

*A Design for obtaining a Mechanical Power from the mere Motion of the Waters; and for distributing that Power into every Part of Great Britain, so that the Supply may be rendered equal to any given Demand which may be required.*

Mr. Ferguson defines a fluid to be “a body that yields to the least pressure, or difference of pressures.”—“Its particles,” he says, “are hard, since no fluid, except air or steam, can be pressed into a less space than it naturally possesses.”

It appears to me, that from these properties we may deduce sufficient principles to justify an experiment upon the mere motion of the sea; for there seems to be no doubt that the force by which the flowing tide is impelled, does at all times yield a difference of pressure, of sufficient importance to overcome the resistance which may be impeded by an equal fluid in a state of rest: for as  
each

each particle is equally free to move, it will always move towards that point where there is the least pressure, and recede from that where there is the most.

Let an air vessel, for example, be constructed with a valve near its bottom, and a main pipe ascending from its side: let it then be filled up with water; then fill a common syringe with water, and inject it through the tube which contains the valve: I apprehend there can be little doubt that the water contained in the vessel will rise in the main pipe in proportion to the quantity injected; because of the force applied to the syringe, which affords a difference of pressure upon particles otherwise equal. Upon a similar principle a wedge is made to cleave the same tree, or enter the same timber of which it is formed, by means of the stroke or pressure applied.

There is a copying machine invented, by Mr. Bramah, which acts by means of a very small forcing pump. This injects water into a cylinder, so as to move a piston and table upwards. I am told that the power of this little contrivance is so great, as to press a block of wood to pieces which is six inches

inches square: I have not seen this experiment.

Mr. Foulds, at the London-bridge water-works, has approached still nearer to my idea, by combining the properties of fluid matter through the help of an air vessel; thus availing himself of elasticity, for the purpose of filling the mains of the London-bridge water-works, which were formerly supplied by means of an elevated tower, constructed on the simple fountain principle; into this the water was raised by the same forcing pumps which are now applied to the air vessel; and was from thence distributed from the tower into the mains of the water-works.

The chief difference between Mr. Foulds's method and my conjecture is, that I suppose the motion of the tide, when governed by a proper direction, will be fully competent to open the valves of an air vessel; by which means the water will be injected and raised into the mains by the elastic action of the compressed air upon its surface, as in the case of the London water-works, without the force of any additional power.

I do not pretend to form an obstinate conclusion, that this is the only method that will

will answer; that this is complete in itself without amendment or aid; that this is either without objections to it, or am I certain that it will answer at all. It strikes me as a design worthy of experiment, although I perceive some difficulties to be overcome; such as the filtage of the sand which the sea brings with it: this may happen to choke the valves, or fill up the air vessel and ducts: it may be requisite to contrive successive valves to meet the rise of the tide, and to shut each other by means of a click or spring: there is also a necessity to bring the fluid into a state of equilibrium within and without the air vessel, before the valve will open at all; and to this must be added the motion of the sea, from whence the difference of pressure or preponderance is to be expected. Successive lights, however, will arise from an investigation of the subject; and I am induced to hope that these would amply reward the inquiry.

It may perhaps be still farther necessary to add some small power by means of machinery, to help the action of the air vessel; but if even this succeeds, it will be an inestimable acquisition to agriculture, manufactures, and commerce: for I have no hesitation

tion in saying, that the present system of practical hydraulics is, in many things, imperfect, partial, and puerile; and that it may be amended in the items of inland navigation, irrigation, and drainage, as well as in respect to mechanical application, and the watering of towns and cities. I will even add, that if the whole of the demand for irrigating the kingdom entirely through every part of it is to be supplied, by machinery, from the lakes of Cumberland, &c. or from the flow of the tide, and by the total application of machinery, that the Government may draw a powerful revenue from such a national operation; and the country would be enriched by it, to the advantage of all its inhabitants.

This position applies equally to Scotland and to Ireland; and, indeed, to every other country; for all countries have what is termed a back bone, land's height, or highest point or ridge of elevation between the waters which discharge themselves one way, and those which run in another direction: yet so attentive are mankind to individual interests, and so limited have been the mere local operation of civil engineers, that the savings of wealth which a combination of  
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he very powers that have been separately applied would have produced, seems to be a subject which has not occurred to them. But it is nevertheless a topic which admits of ample demonstration; and of estimates, founded on experience, which may be made to approximate nearly to a practical result.

Suppose, for example, that Government were to take into their own hands the construction of *one grand national water-work*, for the purpose of elevating a sufficient supply of fresh and salt water from the most convenient waters below, to the most elevated hills, mountains, and peaks; forming spacious reservoirs in the coves or these steril regions; and that a grand communication, by mains, pipes, and canals, was formed from one hill or eminence to another throughout all the dividing ridges which separate the principal waters and rivers of the kingdom. There could, in this case, be no doubt remaining, upon principles long proved by practice, that from basins or reservoirs erected near these summits, water would distribute itself afterwards by the mere act of its own gravity, duly registered or governed by air tubes, into every acre in the island; and from thence discharge its surplus  
to



to the sea, through the ordinary sewers which nature has designed.

This capacity being thus once obtained, the supply would be always regulated and justified by the extent of the demand; and, from hence, all the smaller drains of private navigation, culinary purposes, irrigation, and manufactures, might be furnished at a moderate rent. This would complete an inestimable system of public economy, mutually redounding to the benefit of the crown and the subject, and highly honorable to British science, and to this age of superior improvement.

If we wish, however, to be moreover satisfied in regard to the pecuniary advantages which may be made to flow from this medium of public economy, we are furnished with accurate data for an estimate which may approach near enough to our purpose to form a satisfactory fiscal calculation. The heights of the principal hills and mountains in England are as follow :

	<i>Feet.</i>
Skiddaw, in Cumberland, is above	
Broad Water — — —	3300
Axe-Edge Peak, in Derbyshire, is	
above Derby — —	2100
Bunster Hill, in Staffordshire, is above	
Trent — — —	1200
Exton Hill, above the level of the	
Dove — — —	700
And Dartmoor, above the sea, about	1000
	—
Making in all these summits -	8300
	—
The mean elevation being - -	1650
	—

The point of partage of the Grand Trunk Canal, which traverses the heart of the kingdom, through the county of Stafford, in its way from Liverpool to Hull, has a rise of 316 feet, and a fall of 326 feet, yielding a mean elevation of 321 feet, which may, I think, be fairly taken as the medium partage between the rivers of England that empty into the British ocean, and those which disembogue themselves into the Irish sea.

By

By an admeasurement upon Mr. Cary's large map, I find that a main trunk or canal, of six hundred miles in length, would be sufficient to extend a supply of water throughout the kingdom, from the boundary of Scotland to the Land's end, along the dividing ridge, or most elevated land in the country; from whence its own gravitation would convey it everywhere else, through the pipes and canals of individuals, or of associated companies: but, to render the distribution more complete through every part of the kingdom, I will add nine hundred miles more as an allowance for public branches along the principal dividing heights, and take a greater number of elevations into the account, so as to estimate the national distribution of water to be a main of fifteen hundred miles extent, having its reservoirs elevated at the average rise of 900 feet; which is nearly a mean between the mountain summits, and the partage of the Grand Trunk Canal.

Thus, I presume, every objection will be removed in respect to the principle; which, like that whereby the human body is supplied from the grand reservoir of the heart into the smallest arteries of the head, the

fingers, and the toes, would distribute its bounteous influence into the most distant canal, into every mill-pond which should be desired, into every farm and garden which should be cultivated, into every tan yard which requires it, into every bath, cascade, and fishpond of luxury; into every fountain of ornament or use which might be desirable; into every house which should be inhabited; into every kitchen which should cook a dinner; and into every water closet which should accommodate the remaining occasions of the family.

But it is a misfortune which I have often observed, that men are prone to confound a principle, from which you calculate with a design to incur the whole expence. Now, as I admit a very material distinction between what is theoretically possible, and that which is practically expedient, I think it proper to premise an explanation before I attempt an estimate. I would have it understood, that it is my opinion that all elevated countries, which neglect to construct an elevated navigation, are pursuing a defective system of canal conveyance: a system which bids fairly to exhaust the natural supply of water, to  
silt

filt up the natural sewers of the country, to injure the depths of river navigation, to create ill blood and strife between party and party, and to terminate in a thousand disappointments, because there are not springs enough for every man.

Hence it is that I would have the *nation* to begin at the right end of the business, by obtaining a command of water which should be competent to all its occasions ; and I will endeavour to make a sufficient estimate, to shew the nature of the expence and profit, which I contemplate ; but I would not have it from thence inferred that I would expect a prompt execution of the design : it is sufficient to lay out the plan, and carry into effect such parts of it as may be found progressively convenient ; for whether such a design has a capacity for completion in five years, or five hundred years, is a matter resting wholly upon contingencies, and must greatly depend on its points of remuneration. It should be nevertheless remembered, that every great national undertaking has its beginning ; and it is certainly highly honorable to the reign which commences such works of bounty and munificence.

It would be advisable in an undertaking of this nature, that if the cost of machinery cannot be done away by the substitution of some such invention as I have endeavoured to contrive an application of to the mere motion of the sea, that the expence should be reduced so far as it may be found practicable, by the adoption of co-operative powers. The horizontal wind-mill is one which may be applied to great advantage in all windy situations; for it matters not in what direction the wind comes, or that it is attended; yet it will always be found a self-acting machine, whensoever the wind blows at any point: and by this means a considerable quantity of water may be also forced into the air-vessel, independent of the action of the tide.

Indeed I think it will not be very difficult to contrive a helping machine to the motion of the valves, which it is necessary to govern with mathematical nicety.

By the help of surface-conductors the rain may be collected from the mountain tops into the various reservoirs which hilly countries generally admit of in cheap and sterile situations, to a very considerable extent; into these, according to their various levels,

levels, many little streams of water may be directed ; and numerous instances will occur, where the assistance of the cheap lifting-wheel, which I have herein before described, will re-elevate the overflow to basins on a higher eminence ; from whence it may be again distributed in droughthy seasons. There is, under contemplation of this little branch of economy, one circumstance to which I beg leave to call the attention of every man who manages a farm. The cheapness of this last machine brings it within every farmer's reach ; and if he will only be at the pains to use it, during the time for manuring his grass lands, for the purpose of mixing liquid manure in a pit properly situated for distributing such into surface-drains through his grounds, he will find himself wonderfully rewarded by an abundant crop of grass, of the richest quality, even progressively from the barren heath.

But when we are estimating a design in order to determine its expediency, it will always be found safest to allow the most expensive methods ; which will not only ensure less disappointment in any case, but will also leave more room to spirit up the execution

tion by the successive amendments which may occur.

I shall therefore make the actual practice, in water-works moved by the power of steam, the basis of my calculations ; and if I should fortunately succeed in any new method or improvement, by which a national saving shall be attained, I trust I shall at least reap the credit of it, although those who have the benefit of a more fortunate patronage may be more likely to enjoy its pecuniary advantages.

*Of the Power and Expence of constructing a National Irrigation ; and of communicating a Regulating Main throughout the Kingdom of England, to be fed wholly from the lower Level of the Tide, Lakes, and Rivers, by Means of Machinery.*

In pursuing this inquiry I shall adopt the principle of safety which I have just laid down, and shall found my calculations on the most expensive machinery.

In my Political Economy of Inland Navigation, Irrigation, and Drainage, published  
last



last year by Mr. Faulder, in Bond-street, in calculating the power and expence demanded in my plan for insulating the city of London by means of a navigable canal, I have taken the actual practice of the steam engine which is employed daily in the Shadwell water works as my datum ; and I have, in that work, gone into many detail considerations and estimates which may be easily referred to, and which it would be, therefore, superfluous to repeat.

By this engine the water is raised ninety feet ; its pump-barrel is twelve inches ; and twenty-two strokes, of six feet each, are performed in one minute.

The cost of this engine is estimated at two thousand pounds ; and its consumption of coals at two bushels per hour.

Now as I have fixed the mean perpendicular height of the proposed national reservoirs at nine hundred feet elevation above the lower level, I will first endeavour to calculate the expence of commanding so much water at pleasure, for the support of a regulating main ; and of distributing its influence, from the reservoirs, through every part of the kingdom.

As the surplufage of one such main, confined

fined merely to the demands of irrigation, when the drought of the season may happen to exhaust the due proportion of humidity, would probably be of sufficient importance in itself; and more particularly as any greater demand for canals, factories, mills, fish-ponds, cascades, pleasure fountains, &c. will carry with it an increase of income to the water works, from whence they will necessarily draw an accumulated profit sufficient to justify additional pipes: it will suffice that we take this limitation of the subject as an ample basis for every further extent of it.

It should be held as an invariable rule in the general practice of raising water, or boats, in hydraulic operations, that where the rise or fall can be brought to one single rise or fall of the land which divides the higher and lower levels of a country, the work for doing this should never be divided; for it is plain that every repetition of such a transfer must repeat a great proportion of the machinery or lockage as often as the operation is to be repeated; besides the increase of attendants, and delays of repeating process. In theoretic calculations it is, however, of some importance, for the reasons  
before

before assigned, to estimate repeated, perhaps unnecessary operations.

Hence, as Shadwell engine raises its water ninety feet, at a known expence, I will allow ten such engines to reach nine hundred feet elevation in the proposed national water works ; and one grand reservoir, besides a set of regulating basins, to equal each twenty-five miles of main, throughout the fifteen hundred miles that I have proposed the extension of national mains, from Scotland to Cornwall.

### *Of the Expence.*

According to the foregoing premises it will be perceived, that six hundred steam engines, of the value of one million two hundred thousand pounds, consuming two bushels of coals each per hour, amounting to four thousand eight hundred and sixty-six and two-thirds chaldrons of coals for each ten engines ; or two hundred and fifty-two thousand chaldrons, per annum, for the whole kingdom will be demanded ; which, at the good average price of forty shillings per chaldron, would be five hundred and four thousand pounds for fuel.

There

There will be a demand of eighteen thousand yards of elevating main, to raise the water from the lower level to sixty grand reservoirs, each nine hundred feet above that level; this item, say, at two hundred weight of cast iron to each yard of twelve inch pipe, and five-eighth metal, (which will easily bear a hundred feet column of water), amounts, at fourteen shillings per hundred weight, to the sum of twenty-five thousand two hundred pounds.

Wooden pipes, cartage, laying down, extra charges, &c. inclusive, for fifteen hundred miles of regulating main, at twenty shillings per yard, will amount to two million six hundred and forty thousand pounds. Say for sixty grand reservoirs, at two thousand pounds each, one hundred and twenty thousand pounds; and one hundred thousand more for regulating basins, buildings, &c.

Thus the aggregate cost of construction may be stated as follows:

600 Steam

600 Steam engines, each 2000l.	£.1,200,000
1800 Yards of elevating main	- 25,000
1500 Miles of regulating mains	2,640,000
60 Grand reservoirs, each 2000l.	120,000
Regulating basins	- 100,000
Allow largely for contingencies	915,000
	<hr/>
Total cost,	£.5,000,000
	<hr/>

It follows to state the interest for which this sum may be obtained on so eligible a security; and to add the yearly charges which are attached, before the probable balance of national gain can be ascertained or remunerated: and, as the government are all competent to regulate the rate of interest, I will suppose the sum of ten per cent. per annum to be sufficient inducement. Hence the following will be approximate to

The annual expence,	
Loan of five millions, obtained at	
ten per cent. interest	£.500,000
	<hr/>
Carried forward,	£.500,000
	<hr/>

Amount

Amount brought forward	-	£.500,000
Consumption of 250,000 chal-		
drons of coals, at 40s. per chal-		
dron	- - - -	504,000
500 Superintendants of different		
descriptions, averaging 200l.		
inclusive	- - - -	100,000
Wear and tear, disappointments,		
casualties, new works, and		
contingencies	- - - -	396,000
		<hr/>
Total of annual charges,		£.1,500,000
		<hr/>

This annual expence will, I apprehend, be sufficiently powerful to govern the temperature of the seasons, and to direct elementary blessings into the coffers of the kingdom, if it should be thought proper to execute the work for public account and risque, by means of monies to be loaned on the faith of this great improvement. I will next endeavour to illustrate this lucrative prospect, by opinions and facts of the highest authority; and which must greatly overbalance the weight of my own arguments in the scale of popular conviction.

*Of certain Advantages which may accrue to the Government, and to its Subjects, from the Construction of grand National Water Works, as herein proposed; and from thus irrigating the steril Lands of the Kingdom by the same Means which supply our commercial and culinary Purposes.*

Several of the principles which I have conceived to be most applicable and efficient towards producing the inestimable ends which we are looking to, were hinted at in my last year's plan for insulating the City of London, and bestowing all the appendant advantages of a navigable canal upon the metropolis and the surrounding country; and the theory and practice of hydraulic operations were still more enlarged upon in my general work, *The Political Economy of Inland Navigation, Irrigation, and Drainage.*

As I am at present, however, to aim at convincing society that my designs are practicable, I presume the facts which exist in other countries, or which are entitled to faith in this, upon the respectable state-

ments and opinions of such men as Arthur Young, Esq. Sir John Sinclair, and Mr. Middleton, will be received as admissible evidence in the cause of approximate conviction.

It is known to the world, that Mr. Young, now Secretary to the Board of Agriculture in London, made a tour of agricultural observation through France in the years 1787, 1788, and 1789. That tour was published in London in 1792; and I have now the pleasure of appealing to the interesting testimony it affords me on the capacities of irrigation. I do this with more heartfelt pleasure, in as much as these improvements apply with interesting propriety to many, impoverished soils in my native county of Cumberland, and the country adjacent: indeed it is a very natural inclination for men to be zealous for the prosperity of their natal spot, and I heartily join the Bishop of Landaff in fervent prayer, \* "that while there is an acre of such waste improvable land in Great Britain, no inhabitant of this island may be driven by distress," or by the inhospitable

\* The Bishop's preliminary observations to the Agricultural Report of Westmoreland.



persecutions of his relatives, "to seek a subsistence in Africa or America!"

Mr. Young says\*, at Perpignan, the richest arable of the vale at Pia, sells, if not watered, at 600 liv. the minatre, (20l. 9s. 6d. per acre); but the watered lands at 1000 liv. (37l. 9s. 10d. per acre). † At Campan, lands, with water at command, sell at 600 liv. the journal (49l. 17s. 6d. per acre), of 700 cannes, (about 19,600 feet); but not watered, from 300 to 400 liv.

At Falaise, this same author informs us of ‡ a vale of watered meadows that produce 100 liv. per acre, 22 feet to the perch, (3l. 10s.)

At Montelimart, he says§, close to the town, a septier, which is one-half of an arpent of Paris, let sat  $2\frac{1}{2}$  louis d'ors, or five the arpent, 120 liv. (6l. 2s. 6d. per acre.) At a distance 60 liv. with obligation to dung every second year, which is remarkable: 100 septrees, that receive the washings of the city, lets at 5000 liv.; besides 600 liv. for the winter feed of sheep.

At Avignon, he tells us, irrigation is car-

\* Young's Tour to France, p. 363.

† Ibid. p. 364.

‡ Ibid. p. 364.

§ Ib. 365.

ried on in great perfection, by means of the waters of the river Durance, and the Crillon Canal, made only for the purposes of watering. The meadows are mown thrice a year, producing from 30 quintals of hay, at 40 to 60 the quintal, on each eymena of 21,600 feet, (7 ton 14 cwt. per acre), at three cuts. Such meadows sell, near the town, at 1000 liv. (76l. 10s. per acre); further from it, 800 liv. (61l. 5s. per acre).

In page 368, this Gentleman adds, in relation to irrigation: "It appears, that in some parts of France, particularly in the southern provinces, this part of rural economy is well understood and largely practised; but the most capital exertions are very much confined: I met with them only in Provence, and the western mountainous parts of Languedoc. In the former canals are cut, at the expence of the province, for conducting water many miles in order to irrigate barren tracts of land: in England we have no idea of such a thing. The interests of commerce will induce our legislature to cut through private properties, but never the interests of cultivation."

Again, says Mr. Young, \* The diffe-

\* Young's Tour through France, p. 369.

rence in value between cultivation, watered or not watered, is not greater there than here, except on arid and absolutely barren lands, on which the difference arising from climate is certainly enormous. Under a hot sun, and in a comparatively dry climate, like that of Provence, sandy or stony tracks, such as La Crau, yield, comparatively speaking, nothing; but watered, they become clothed with the richest verdure, and yield the finest crops. In regarding, therefore, the latitude of a country as an index for ascertaining the degree of improvement effected by irrigation, theory would deceive us greatly. Water gives many other things besides humidity; it manures, consolidates, deepens the staple or surface mould, and guards against cold; effects as obvious in a northern as in a southern climate. He concludes this subject by recommending this most obvious and important object, as one of the first in the circle of rural economics.

Sir John Sinclair, in urging this subject to the attention of the members of the Board of Agriculture, of which he was then President, says, (I presume without contemplating any general design, like mine, for

raising water ), \*<sup>“</sup> at least a million of acres of the waste lands of the kingdom may certainly be brought to an astonishing height of cultivation by watering or irrigation. This great means of improvement, though long established in some parts of the kingdom, yet in others has been unaccountably neglected. But when once that art is extended as it deserves, the advantages to be derived cannot be easily calculated; for by it land is not only rendered perpetually fertile without manure, but the luxuriant crops which it raises produce manure for enriching other fields; and the manure obtained from that produce is another source of national wealth, that could not otherwise be looked for. Thus, says he, there is every reason to believe that the wastes of the kingdom, if planted or appropriated for pasture lands, or cultivated for the production of grain, or converted into mead, or improved by means of irrigation, must necessarily be the source of infinite wealth and benefit to this country.

And if, continues he, there is a possibility of improving our wastes, the means for that

\* Address to the Members of the Board of Agriculture, 1795, p. 20.

purpose are more abundantly in our power, than perhaps in that of any other country in the universe. Without entering much at length into so wide a field, it may be sufficient to remark, that there is none with such a capital capable of being devoted to so useful and profitable an object; none where such a spirit of exertion exists, were all obstacles to the improvement of our wastes removed; none where there is such a mass of knowledge on agricultural subjects; none where such abundance of manures are to be found, particularly those of a fossil and mineral nature, without the aid of which it would be impossible to bring great quantities of waste lands rapidly into cultivation; and, lastly, none where, by means of a series of excellent roads and canals, everywhere rapidly extending, such manures can be so easily and cheaply conveyed to the lands they are calculated to fertilize. These are advantages for improving wastes, which no other country enjoys in equal perfection; and which would soon be the means of cultivation of a very large proportion indeed of our at present useless territory, if full scope were given to the industry and exertions of the people.

Nor ought the wealth to be derived from the improvement of our wastes to be alone taken into consideration: the increase of population, and, above all, of that description of persons who are justly acknowledged to be the most valuable subjects that any government can boast of, merits to be particularly mentioned. His mind must indeed be callous, who feels himself uninterested in measures, by which not only the barren waste is made to smile, but of which the object is to fill the desert with a hardy, laborious, and respectable race of inhabitants; the real strength of a country being the fruitful nursery, not only of our husbandmen, but also of the fleets, the armies, and the artists of the nation. The additional number of inhabitants who might thus receive occupation and subsistence cannot easily be ascertained; but, if the present population of Great Britain amounts to about ten millions, these wastes and commons, properly improved, might be the means of adding at least from two to three millions."

Mr. Middleton has thrown considerable lights on the great benefits which are to be derived from a regular system of irrigation.

\* Irrigation,

\* Irrigation, says he, makes no part of the practice of a Middlesex farmer; he suffers the streams to glide by, or through his farm, without interruption; and looks on them merely as conveying the surplus water out of the county. When the summer's heat is burning up his crops, his only hope is in an early rain: he never thinks of supplying the deficiency of moisture by art. And when the winter's flood overspreads his fields, in some cases he bewails his misfortune, but dreams not of embanking the land. If his farm is exhausted, he resorts to the London dunghills, forgetful of the streams that are running through it, loaded with fructifying particles.

The improvement of land by irrigation, says Mr. Middleton, is of the very first importance. Wherever the water of this county can be flowed over, and afterwards drained off, any kind of land, at pleasure, be it ever so poor, may be laid to grass; and by the effect of water alone, raised to the highest pitch of perfection which meadow land is susceptible of. This is not only

\* Agricultural Report of the county of Middlesex, p. 316,

a great improvement, worked without manure in the first instance, but the land will never want any, or at least not more than it will meet with in the water. The largeness of the produce of watered meadow is, at the same time, a fund for dressing other lands, and particularly valuable to every cow farmer. No other mode has yet procured such early spring grass; and the hay, when mown early, is peculiarly suitable for cows, being soft and succulent. As a cow pasture, no other land would support half so much stock.

The produce of meadow land in this county is ten pounds an acre per annum; of the arable land, in common fields, eight pounds; light land, inclosed, thirteen pounds. Any of the foregoing soils would produce fifteen pounds, if watered meadow.

\* Mr. Middleton farther relates, that in Hanworth Park there are about sixty acres of watered meadow that are less perfectly managed than usual; yet in the middle of September, a lot of twenty acres of this meadow was from six inches to a foot deep, in after grass of the most luxuriant quality;

\* Agricultural Account of Middlesex, p. 318.



when all the unwatered grass was nearly burnt up. A piece of the same park, in meadow duly watered, containing forty acres, in another instance, had supported forty-seven horses and bullocks, in a mixed stock, for three months. On the adjoining land, of similar kind, manured, but not watered, the cut of the scythe remained still visible where the former crop had been mown. Were we to search for a proper site for experiments in this interesting science, or for a point of concentration from whence the benefits of experiment and example might find a centrifugal distribution into the world, which would do honor to the reigning prince, and add lustre to the antient spirit of English munificence, I conceive the universe does not afford a more suitable field than the counties of Middlesex and Surry. The city of London is unequalled in the annals of commerce and improvement; and its surrounding suburbs and country may be rendered equally so in horticulture and aration. No river in the world, perhaps, receives so plentiful a supply of fructifying particles as the Thames, into which the sewers of London are disembogued; nor does any river in England offer an equal medium  
of

of distribution for the fertilizing materials with which the tide is daily charged from this resource; independent of the interior washings into its streams, which that able agriculturist, Mr. Middleton, has very amply detailed.

There is no place on earth where gardeners might so highly improve their grounds, and ease so much of their labour by cheap and easy machines, as in this neighbourhood; nor is there any spot of the globe where the husbandman might adopt, with greater profit, the method practised by the German farmers in America, in the use of liquid manure: these people seem to be among the first who have discovered the advantages which arise from this very essence of fertility: and from the means of commanding its distribution, at proper seasons, along the drains and slopes which their grounds admit of, from a farm-yard, or reservoir on the summit of the field\*. All the practical farmers, where I have seen the use of this or simple irrigation, are not only

\* See also Mr. Joseph Farmer's Communication to the Board of Agriculture on this subject. Communications to the B. of Agric. Vol. II. p. 342.

attentive to the season of the year when such moisture is necessary, but to the hours of the day : for if water is thinly turned upon grafs, and permitted to stand during the extreme heat of the sun, it will scald the roots more or less, and destroy the principal means of vegetation ; but if the trenches are so conducted, that water can be at all times commanded and turned upon the grafs about sunset, permitting it to run speedily off after an overflow of about an hour, it will be found as effective to the full as, or more so than, a fine natural shower ; and the next morning will present a fine pearly dew, although the earth in general should be highly parched, and a dust.

On the other hand, in respect to clayish or boggy land, such as is apt to retain the water in every hole or foot-mark of an animal, a system of irrigation, accompanied with a due attention to draining, would give an equal command of the seasons by art ; for perfect irrigation must always contemplate the means of commanding water, bestowing it upon the crop, and turning it speedily off at pleasure. Both theory and practice confirm these points, and they cannot be too much imprinted on our recollection.

. Mr.

Mr. Middleton, in speaking farther of the advantages which farms in general may enjoy at the mere expence of their individual proprietor, observes, that\* a power, effectual and cheap, for raising the water in sufficient quantity to flow about ten acres at a time, would be invaluable; as nearly all the landed estates in Britain might be improved by it. Should the power be acquired, he says, be it to work by horses, wind, water, or steam, innumerable are the uses to which it might be applied. The most obvious to a farm are threshing, winnowing, cutting chaff, raising water for the use of the family and of the cattle, the grinding of malt, linseed, and corn; but, above all, the raising of water for irrigation.

Forty acres of good water meadow, he adds, will support, in the greatest luxuriance, 500 Wiltshire ewes and lambs for six weeks, from the middle of March to the 1st of May; during which time they will improve one shilling a week, or pay three pounds fifteen shillings per acre, at a time of year when all other farmers are distressed for a want of food for their stock. In

\* View of Middlesex, p. 322.

Middlesex it would be still more valuable, as five pounds worth of hay might be mown off in the first week in May.

The best water meadow is probably the mark of perfection in the management of a farm: it follows, of course, says he, that every possible exertion of labour, art, and machinery, should be employed to flow as much land as possible.

The general features of highland meadows in the neighbourhood of London, when compared with the neighbouring commons and wastes, as well as the remarks of Mr. Middleton on a subject for which he seems so abundantly capable by native talent, long experience, and minute observation, go fully to shew that these comparative extremes of fertility and impoverished soils, have in former days claimed nearer affinity; and they now afford a striking contrast as the best convincing example of the general capacity of the kingdom: one which certainly demands the attention of the nation, when the concentrated pleasures of dissipation will permit our country gentlemen to have leisure to notice such a happy result of experience, and to remunerate themselves, through a return of its bountiful influence, in their rural concerns,

cerns, as a small degree of recompence for the deteriorations of the city.

Sir John Sinclair corroborates these testimonies of the arable capacity of the kingdom, in respect to its waste lands, by comparing the state of the markets at distant periods of time\*. In the reign of Queen Anne, says he, when half the stock of the kingdom were fed on commons, it is hardly to be credited, in 1710, the cattle and sheep, sold at Smithfield market, weighed, at an average, as follows:—Beeves 370 lb.—calves 50 lb.—sheep 28 lb.—lambs 18 lb.

*Now*, it may be stated—beeves 800 lb.—calves 148 lb.—sheep 80 lb.—lambs 50 lb. The increase is principally, if not solely, to be attributed to the improvements which have been effected within these last sixty years, and the feeding of our young stock in good inclosed pastures, instead of wastes and commons: add again to this account, the inestimable benefits of irrigation.

If I may be permitted to furnish proofs of extraordinary productions in the present highly improved condition of English stock, I may be indulged in stating, that at the

\* Address on the Cultivation of Wastes, &c. p. 5.

Vine tavern in Stafford, where a considerable meeting of respectable farmers is held on market days, I had the pleasure of seeing in the month of January 1798, a sample of mutton exhibited by Mr. Princeps, of or near Litchfield, from a sheep, which the farmers present called his small breed. The weights, as then related to me, and noted on the spot, were as follow :

		lb.
The fore quarter	-	40
Hind ditto	- -	32
		—
	Per side	72
		2
		—
The 4 quarters	-	144
5th Quarter at average		36
		—
		180lb.
		—

The prize sheep, for the year 1799, lately exhibited among other competitors for this laudable species of premium, was of the old Gloucestershire breed, bred and grazed by Mr. Poulton, of Crickdale, Wilts.

He was killed by Messrs. Hiscock and  
Q
Farrow,

Farrow, of Reading. He measured six feet five inches and a half in girt, twenty-seven across the back, twenty-two inches over the shoulders, and stood only twenty-six inches high. His depth of fat was, on the rump, eight inches, on the ribs six and a half inches; and his weight twenty-seven stone\* and seven pounds.

The fat hog, belonging to Mr. William White, of Kingston in Surry, killed 28th March 1798, was—

4 feet high,	$2\frac{1}{2}$ years old,
8 feet long,	49 score 6lb.
9 feet 2 inches girt,	70 stone 6lb. at 14lb.
5 inches fat all over,	per stone,
	123 stone 2lb. at 8lb.
	per stone.

It was generally allowed that this hog might have been fed to double this size.

The prize heifer, was bred by the Duke of Bedford, and purchased by Mr. Hoad, of Wapping, for forty pounds.

\* The stone of meat is 8lb. horseman's weight, 14lb. and said to be 16lb. per stone in some other cases unknown to me.

*Her*



<i>Her measure.</i>			<i>Her weight.</i>		
	f.	i.		ft.	lb.
Height -	4	2	Weighed -	107	7
Girt - -	8	2	Tallow -	14	0
Length -	7	0	Hide -	8	0

The prize ox, was fed by Mr. Westcart, of Buckinghamshire, and purchased by Mr. Chapman of Fleet Market.

<i>He was</i>	<i>Weight.</i>
6 feet 7 Inches high,	*241 Stone 3lb.
Girt 10 feet 4 inches,	36 Stone—4 Tallow,
Length 9 feet,	29 Stone—0 Offal.

I have before stated, that I am particularly desirous to see the introduction of irrigation into the Northern Counties, as one of the primary means of improving the extensive wastes, more especially of Lancashire, Yorkshire, Cumberland, and Westmoreland. Concerning the last of these counties I have had many conversations, and have often been opposed with the arguments of impracticability: that there was nothing there to pay

\* Mr. Jefferson states the heaviest cattle which he had known to have been weighed in America, as follows:—Cow kind 2500lb.—Hog 1200lb.—Sheep 125lb. See Jefferson's Notes, p. 80.

carriage upon a small canal, no land worth improvement, and that the climate was unfriendly to culture, &c. ; as if gentlemen were predetermined to shut their eyes against conviction, and jog on in the old beaten track of their ancestors, notwithstanding the advancement of science, or considerations of private income.

In regard to the improvement of the Lancaster and Ulverstone sands, (which *I* have no hesitation in supposing capable of reduction to a permanent ship channel of a considerable capacity, and to a vast acquisition of verdant meadow, which would amply repay the adventures of speculation), I am led to despair of seeing any man successful in bringing the parties most concerned to view the operation as a thing practicable ; more especially as I have learnt, that the efforts of Mr. Wilkinsons talents, the offers of his purse, and the influence of his fortune, have been insufficient to awaken the neighbouring gentlemen to a sense of their own, or the national interest in this great undertaking.

I have, however, been at some pains to impress the idea of such a small interior undertaking, as should afford an easy transfer  
by

by water through the Westmoreland Lakes ; for the distribution of sea sand as a manure for the barren heath, and an easier return than the present mode affords, for the slate and materials which have already forced their way to market.

In answer to this proposition I have been frequently told, that it had been long ascertained that the design was impracticable, or at least very doubtful ; that the place had been surveyed long ago, and the undertaking discountenanced ; and that the country afforded nothing to carry.

I find on a later inquiry, that about twenty-eight years ago some gentlemen of the neighbourhood took an eye-view of the premises, and being perhaps, from this very slight attention to the subject, thus persuaded at that period, the opinion of the fathers has been swallowed by the children. I learn that such a communication, at the present day, would at least accommodate transfer for a set of iron works upon the Lakes ; a fine cotton manufactory ; considerable quantities of slate, lime stone, and charcoal ; besides their respective returns ; the articles of sea sand, and other manure ; the ordinary occasions of the country ; the fishing of the Lakes and sea ; the prospects of fu-

ture forests and agricultural productions ; and the various acquisitions which result from irrigation.

\* In regard to the climate of such wastes, says Sir John Sinclair, it is evidently worse for the want of cultivation. At the same time, from the insular situation of Great Britain, the climate is infinitely milder and better than in any part of the Continent, of the same latitude. It is stated in one of the reports, on the most respectable authority †, that very fine barley and oats ripen in due season on the summit of a hill in Forfarshire, elevated 700 feet above the level of the sea ; and that in Invernesshire, at an elevation of 900 feet above the same level, wheat of a good quality has been grown. Hence it may be inferred, that grain, and other articles of a similar nature, may be raised to such a height upon the sides and summits of all the hills in the island ; and, in regard to grass, it is well known that luxuriant crops of hay are obtained at the Lead Hills in Lanarkshire, elevated 1,800 feet above the sea. The climate of this country, therefore, can

\* Address on Inclosed Lands, &c. p. 19.

† See Prelim. Observ. to the Report of Forfarshire, by G. Dempster, Esq. p. 6.

hardly be urged as an objection to the improvement of the greater part of our wastes; either for grain or grafs : as to trees, it is not to be questioned that the *larch* grows in Italy on higher mountains than any we have in this island \*.

In regard to the perfection to which that very useful tree, the larch, may be reared in Great Britain, Doctor Anderson mentioned to me, a few months ago, a sufficient example to call for a more general plantage of them. There is one, he says, in Scotland, of fifty-two years old, which is four feet in diameter, and one hundred and twenty feet high. This proves sufficient to establish the British climate as a suitable element for this kind of culture.

In the Appalachian Mountains, in America, the larch tree grows spontaneously in great abundance and some variety. It seems to delight in a cold clayey soil, of a yellowish cast, which abounds there in many of the deep valleys having a bleak exposure; and it flourishes both in the watery vale at the foot, and from thence up the mountain

\* See Westm. Rep. Prelim. Ob. p. 9. See, also, Mr. Pontey's late pamphlet on the Culture of Larch Trees.

to its arid summit. When I was last in the Tenassee Country, 1793, there seemed to be a sufficiency of young plants in the spurs of the Iron Mountain, (where the Indian Cr  ek road passes from Little's Ford upon Holton River to Wautauga), to stock all the wastes in Great Britain. It might be easy to procure them from thence at proper seasons, because waggons are continually passing from thence to the sea ports of Richmond and Petersburg; and their proprietors would readily attend to the subject if they found an interest in it.

Sir John Sinclair says, the higher situated and the most steril parts ought, undoubtedly, to be devoted to plantations. There is scarcely, says he, any spot however rocky, or any foil, however unproductive, that will not yield valuable timber—an article which we are under the necessity of importing, at a great expence, from foreign countries. At first sight it may seem surprising, that a spot that would not produce a single blade of corn, will yet support the stately pine, or spreading oak. But trees draw their nourishment from sources beyond the reach of smaller vegetable productions, and by their leaves are also supposed to derive additional sustenance

sustenance from the air that surrounds them, or the water they imbibe. - By plantations also, even barren spots may be rendered fertile.

The poorest soils, if covered with wood, from the leaves which fall, and the shelter they receive, improve every year in fertility; and, when the trees are ready for the axe, become, in process of time, fit for cultivation.

“ Many of the higher wastes in the island, says he, may be rendered perfectly dry,” (for drainage and irrigation should be always found in each other’s company), “ and soon converted into excellent upland pasture. There that valuable article, fine cloathing wool, might be grown to perfection. The loftier the situation, and the shorter the herbage, the more valuable it would be; and the price which the article bears, joined to the profit of the carcase on which it grew, would amply compensate for all the expence of improvement.

A much greater proportion of the wastes of this country, than is commonly imagined, might be employed in tillage. The surface may appear barren and unproductive, but stratum may be found below, which, if incorporated

corporated with the soil above, may render it sufficiently fertile. This is a practice in husbandry which has not yet been carried in any degree, to the extent of which it is capable. It is an art pretty much in its infancy, which, when brought to its perfection, must be productive of the most important consequences. As such, it will naturally call for the particular attention of the Board of Agriculture, to ascertain the principles upon which it can best be conducted."

May I not then ask, with propriety, Where are the principles which lay so sure and great a foundation for general improvement as those of *irrigation*? Or, Where are the countries which may be more improved than *Westmoreland, Yorkshire, and the Northern Counties*, through its offices in inland navigation, watering, and draining?

I am aware again, that if I ask where the difficulty lies in extending a canal from the Ulverstone sands into the lakes, that the old hackneyed principle will be opposed to me, without divesting it of its antiquated incumbrances; and that I shall be told that canals are impracticable throughout that steril country, because it has no trade which is  
sufficient



sufficient to remunerate interest upon the monies it will require.

Now my suspicions are, that this mode of reasoning sets out upon a false position, and must therefore end in fallacy. It seems to presuppose that hydraulic genius has been long exhausted, and reduced to standard, without either allowing latitude for the progress of improvement, or remembering a multitude of recent proofs, that very few, if any cases exist, where the expence may not be so proportioned to the object, as to found the enterprize upon some degree of rational experience, and overcome the impediments of nature through perseverance in the paths of art.

If the country was full of commercial riches, I dare say the spirit of the nation would make no great difficulty in extending a canal from Carlisle to Newcastle for a ship of the line; but as this wealth is yet to be subject to the doctrines of acquisition, and the assiduity of industry, the site is not sufficiently ripened for such an undertaking; and possibly other plans may prove equally as deceptive, when begun at the wrong end of the business, and limited by sturdy precedent,

cedent, and by an obstinate twenty-five ton boat.

If we were to judge comparatively of an Englishman and a Frenchman, from the contempt which the former is wont to bestow on the latter, one would imagine that a native of Great Britain should be ashamed to be indebted to his inferiors for precedents of enterprize: yet it has, somehow or other, so happened, that these contemptible Continentals have executed an undertaking at Languedoc, which holds out precedents to Newcastle; and have irrigated the barren district of La Crau; perhaps a thousand times inferior to those waste lands of Westmoreland, which are producing the moderate sum of one penny per annum per acre for sheep starving; amounting, at twenty-four years' purchase, to the price of an American barren wilderness, a pitiful two shillings per acre\*.

As I happen not, on my part, to be one of those who bow down to the ne plus ultra of human invention, which the Nebuchad-

\* See the Report of this county to the Board of Agriculture, or the recital in Sir J. Sinclair's Address concerning Inclosures.

nezzars of hydraulic perfection may have set up, I am confident enough to suppose it practicable to improve the navigation of the Cartmel and Ulverstone sands, or perhaps to reclaim them; to construct an useful sea port at their head; to extend inland navigation advantageously into the lakes, from Carlisle to Newcastle, and from Rippon to Carlisle: for although none of these may be practicable in respect to immediate commercial returns, they would seem to be all so in regard to agricultural canals and irrigations; and are indeed amply within the powers of finance, and that patience which abideth future remuneration.

In any case it would be a material consideration, if ducts of irrigation only could be extended to the regulation of the seasons. Yet, when we are considering how far the prospect extends of improving a waste and sterile country, in which very few subjects of present commerce exist, to call in the co-operative functions of canal transfer, towards lessening the expence of constructing mains for the purpose of agricultural irrigation, we are called upon by prudence and forethought to look forward into future periods  
of

of time, and to consider what are the probable prospects of produce and material, which the nature of the country may promise to afford from its surface by means of culture, or from the bowels of the earth, by means of art and manual labour. For although the country does not admit of extensive navigation upon a large scale, without merchandise to support it by transfer, yet there are many primary considerations of agriculture which may be assisted by the powers of finance, to extend a small canal into a very sterile country, upon the strength of its future prospects; and such undertakings will be found invariably to carry population and improvement along with them.

*Of cultivating the Larch Tree, in Connection with national Irrigation.*

Mr. Pontey, who has lately written a Treatise on the Culture of the Larch Tree, accompanied with specimens of the wood produced from it, has furnished a demonstration of an ample resource, in this particular,

ticular, towards carrying cultivation to a degree of perfection which many proprietors would scarcely believe ; yet, possibly, throughout the barren moors and heaths of the northern counties : and I am the more induced to credit the universality of his statements, both from the luxuriance of many varieties of this tree, which I have noticed in some of the most steril soils of America, and from the abundant variety of those soils in which I have seen this tree flourish there, in a state of nature, even from the deepest valley to the mountain top.

Mr. Pontey states the culture of these trees, in three-feet rows, at 4840 per acre ; but prefers to plant them in four-feet rows, containing 2722 plants per acre. In the progress of the growth of either, it will of course follow, that the thriving of the trees will regulate the mean product which will arise from successive thinnings of them for transplantation and other uses. He furnishes also an actual example of a plantation of 4194 trees per acre of various sorts, in which the luxuriance of the larch rendered it absolutely necessary to be very attentive to thinning, to prevent the other trees from  
being

being smothered by it. This plantation contained

145,000	Larch
72,500	Scotch fir
50,000	Ash
40,000	Sycamore
45,000	Elms
600	Oaks
600	Spruce fir
30,000	Birch
10,000	Mountain ash
400	Weymouth pine
200	Horse chestnut

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Total 394,300 Trees.

It may afford both satisfaction and occasional data to state, that the trees from which the interesting specimen of larch wood, which accompanies Mr. Pontey's book, was taken, were of about thirty-five years growth, containing about  $28\frac{1}{2}$  feet of timber each, or 199 feet in seven trees, produced by a thin soil, with a loose bottom of reddish yellow sand.

If, by way of example, we take 100 acres of Westmoreland sheep-walk, such as  
Sir

Sir John Sinclair and the Bishop of Landaff have stated, at a rent of one penny per acre, at thirty years purchase, we must call its present value 12l. 10s. Add to this, the sum of 1000l. for fencing and planting; which corresponds with Mr. Pontey's allowance. Each lot of one hundred acres of new plantation completely fenced, would thus be worth 1012l. 10s.; which sum, placed at compound interest for thirty-five years, would amount to 5585l. within a few fractions.

Now if we take the plantation of 100 acres to be in four-feet rows, as Mr. Pontey recommends, there will be 2722 plants to each acre of ground, amounting to 272,200 plants per 100 acres.

And, if we suppose only one third of these trees to come to maturity in thirty-five years, agreeable to the specimen of larch wood exhibited with Mr. Pontey's book, and allow the other two thirds only to equal the cost of attention and repairs of fencing, &c. (which, it is presumed, will be greatly exceeded by the transplanting and other mean profits in the progress of thinning and culture) there will be ultimately

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matured,

matured, in this time, the quantity of 90,733 trees. And, as we may allow each seven trees to yield 200 feet of timber, the produce of each lot of 100 acres will be 2,512,200 feet of timber.

In this way of reckoning it would follow to state the value of this timber, in order to come at the produce of such land by planting it; but as I am not informed on this point, and am without the means of reference, I will adopt Mr. Pontey's method of computation.

This gentleman admits a tract of barren land, so termed for its bleakness, to yield not less than 125l. per acre in standing trees of thirty years growth, valued at 1s. 6d. each, after making every requisite deduction for deficiency and expences: and, according to this method of computation, we may, I presume very fairly, state an account of the outgoings and profit upon a hundred acres of Westmoreland sheep-walks, employed for thirty years in larch plantations, as followeth:

Value of 100 acres land, yielding  
1d. per acre rent, at thirty  
years purchase, together with

fencing



fencing and planting, to the  
amount of 1000l.—both at  
thirty years allowance of com-  
pound interest -

£.4375 18 4½

---

At the end of 30 years, say,

100 acres standing timber,

at 125l. per acre - - 12,500 0 0

Prime cost, or value of land

still remaining - - 12 10 0

100 acres improved by shel-

ter, valued at 9s. per acre,

at 30 years purchase - 450 0 0

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Ultimate value of premises 12,962 10 0

Deduct sum laid out, and

compound interest - 4,375 18 4½

---

Gain per hundred acres by

planting - - £.7,586 11 7½

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Now I will venture to suppose, that if  
this poor barren country in the northern  
counties had no other improvement to expect  
profit from, or no other capacity than that

of growing larch trees, that this is of itself a sufficient inducement to justify the immediate construction of canals; and we will, for argument sake, look upon all other resources out of the question; and they will of course be considered a clear gain, if others should arise unexpectedly.

I will therefore proceed to demonstration on the sole resource of plantations: I will suppose that either Government, or an incorporated company, shall commence an enterprize on the 1st of January, 1801, which contemplates the cutting of canals, and the rearing of timber in conjunction, without any prospect of remuneration till the year 1831, when both the crops of the plantation and the tolls of the canals will very certainly be ripe for retribution. I will allow the proportion of 100 acres of plantation per mile only, to be the quantity of poor land planted by the concern, so as to depend on so much territory in the aggregate, being within reach of the canal or its various ramifications.

To give the subject fair play, I will allow the extent of one hundred miles of main canal to be laid out in a direct line through the country, and one hundred miles of small  
canals

canals to form its distributive branches : let the main canal be stated at two thousand pounds per mile, and the small or branch canal at one thousand pounds per mile, both inclusive, and the account will stand as follows :

*Outgoings upon this Operation for Thirty Years.*

100 Miles main canal, at	
2000l.        -        -        -	200,000 0 0
100 Ditto branch ditto, at	
1000l.        -        -        -	100,000 0 0
20,000 Acres, fenced and planted in lots of 100 acres each, say 200 lots, at 1500l. each        -        -        -	300,000 0 0
	<hr/>
	600,000 0 0
Five per cent. interest upon the above for 30 years, at 30,000l. per annum        -	900,000 0 0
	<hr/>
Total principal and interest	<u>£.1,500,000 0 0</u>

*State of the Property acquired at the end of  
Thirty Years.*

20,000 Acres of land, at 5l. per acre prime cost or value	100,000 0 0
Improved value by shelter, at 3l. per acre, at thirty years purchase, for 20,000 acres - - -	90,000 0 0
20,000 Acres standing tim- ber, at 1s. 6d. per tree, or 125l. per acre - -	2,500,000 0 0
	<hr/>
Land with 30 years crop	£.2,690,000 0 0
Deduct the whole princi- pal and interest expend- ed, to be now paid off	1,500,000 0 0
	<hr/>
Gain (besides clearing the canal) - -	£.1,190,000 0 0
	<hr/>

Thus, if we only admit the mean profits of the canal, grazing of cattle, &c. to pay the trouble of attending to the business, we find, that at the end of thirty years operation, subscribers for shares will have been paid

paid more than seven and a half per cent. per annum for the use of their money; and will have moreover cleared the whole property of the landed estate and canal into the bargain.

Yet much more than this, of right, belongs to the generative faculties of irrigation. In France, Mr. la Lande says \*, the canal of Provence draws, on one thousand toises of its extent, no less a sum than one million of livres per annum rent, for agricultural irrigation alone; and I can see no reason why any of the improvements of England should be either less valuable, or more procrastinated than those of France.

I presume I need give no farther example on this subject; yet it may be proper to subjoin the computations of a learned prelate of the county of Westmoreland, as an authority to keep my own works in countenance, lest they be imputed to a vision.

The Bishop of Landaff, in his preliminary observations, prefixed to the report of the state of agriculture in this county, observes that it may be of use to state the pro-

\* See Young's Tour, p. 368, or Des Canaux de Navigation, p. 175 to 184. Folio, 1778.

bable profit which would attend planting the waste lands of this country with larch trees. He says, “ a thousand acres of this sort of land might be inclosed with a circular wall, six feet in height (where the stones can be easily gotten, as they may in most parts) after the rate of 6s. an acre, or 300l. for the whole; 500 larches, two feet in height (so as to enable them to resist the long grafs) might be planted on each acre for 14s.; hence a plantation of 500,000 might be made for 1000l. Now 1000l. improved at compound interest, at the rate of 4l. per cent. would, in sixty years, amount to the sum of 10,519l.; this is the accumulated loss attending the inclosing and planting 1000 acres of rocky land in sixty years.

The rent of 1000 acres, at 1d. per acre, is 4l. 3s. 4d. a year; in eight years, the larches would be out of all danger from sheep; so that the loss of rent ought only to be estimated for eight years; but 4l. 3s. 4d. a year, though improved after the same rate of compound interest, would not amount to 40l. in eight years; say, however, that it would amount to 81l. which is allowing more than 2d. an acre for the annual rent of the land, then would the whole expence attending

attending the plantation in sixty years be 10,600l. I have here supposed sheep to be shut out of the plantation for eight years ; if it should be found that sheep will not crop the larch, and from more than one observation I have reason to believe they will not, they need not be shut out at all ; nor in districts, where nothing but sheep are depastured, need any fence be made. I know the advocates for close planting, instead of 500, would require 5000 larches for each acre ; I am not convinced of the utility of such planting, except where it is intended to raise up oaks, or other kinds of wood ; but if that mode should be adopted, the thinnings, after twenty years growth, would pay the expence of it.

At the expiration of sixty years, suppose that only 250 larches remained on each acre, or that one half had perished, the probable value of them may be thus estimated. From a great many experiments made by myself, and collected from others, I find the annual increase in circumference of the larch, at six feet from the ground, to be one inch and one half on an average of several years ; and this inference has been drawn from the actual admeasurement of larches in different parts

parts of England and Scotland, and of different ages, from ten years old to fifty. On this supposition, the larches would measure, one with another, ninety inches in circumference, at six feet from the ground. A larch which measures ninety inches, at six feet from the ground, would measure above seventy, at twenty feet from the ground; but supposing seventy inches to be the circumference at twenty feet, and the length of the tree to be forty feet, neglecting the remaining top; then will its solid content be eighty-five cubic feet, and the value of the tree at ninepence per foot above three guineas. But as the trees are supposed to be planted in an high, bleak, barren situation, their annual increase may not be so great as is here supposed; instead of being worth, at sixty years after planting, three guineas a piece, admit that they are worth only ten shillings each, then would the whole plantation be worth 125,000l.; and deducting the whole expence, 10,600l. as before estimated, there would remain a profit of 114,400l.

The present value of 114,400l. to be received sixty years hence, is above 10,000l.  
(interest



(interest of money at four per cent.) Ten thousand pounds, at four per cent. purchases an income of four hundred pounds a year: by planting then, a barren estate, of a thousand acres, is improved from 4l. 3s. 4d. to 400l. a year, reckoning the value of a reversion as a present certainty. Sixty years is a great part of the life of a man; but it ought to be considered as nothing in the existence of a nation, or even of a family, which is a little nation. The waste lands of this and other counties are a public treasure in the hands of private persons; all of them ought to be converted into arable, meadow, or pasture land; which are capable of admitting, with profit, that kind of improvement: and such of them as will not pay for that mode of improvement, ought to be covered with wood: the high parts, and especially the sheltered dells in the high parts, with larch, and the lower with oak, ash, &c."

This estimate of the Bishop's so far exceeds mine, that I trust I shall be deemed very moderate; and I hope that gentlemen will be induced to try their own calculations in various ways.

*Outlines of a Canal System recommended to the Consideration of the Counties of Cumberland and Westmoreland, in pursuance of the foregoing Principles.*

Before I take leave of the irrigation and its relative improvements proposed for the Northern Counties, I am prompted, by a true regard for the prosperity of my native spot, to recommend to its landholders in particular, and generally to its inhabitants, an earnest attention to those powers of combination which art has presented to their assistance as the victor over difficulty: the extension of canals, the irrigation of the soil, and the planting of timber trees, should every where combine to spread a general acquisition of wealth in lieu of their barren wastes; and it is every where practicable, even high in the region of Skiddaw. Mr. Leache's maxim admits canals into every country which has water enough to turn a mill; the improvements of France and of Devonshire have pointed out an application of their surplus water to the enrichment of their soil; hydraulic improvements have established the practicability of giving any degree of surplus water

water to any degree of elevation; and various inclined plains have proved, by practice, that any line of canal may be connected with its higher or lower level, (even over the top of a mountain), although water should prove deficient for the wastage of a pound lock.

In such a state of science, what may not be practised by enterprize and industry? It remains but to calculate the expence; and even that dwindles to nothing in the presence of unanimity. Let us then explore the field of operation; but let us also remember that canals for transfer and irrigation will water most land by keeping the highest convenient level.

I apprehend the first thing to be considered, in all great improvements of this kind is, what lines of direction have been assigned by nature; for these should always pervade the general system, with every assistance which art can bestow; and nothing but some very partial exception will ever be sufficient justification to turn nature out of her course.

Thus it is much easier to conduct a line of canal through a hilly country than a level one, and much safer for the adventurer; for  
nature

nature has said in both cases that she will limit the operation in defiance of the caprice of man, or the competition of evil doers.

Now wherever nature has directed a line of communication, from one great town to another, through an interior country, and thro' a steril one, it becomes interesting to the commerce of both places to join the improvement of the barren waste with the communication of their commercial intercourse and prosperity. The country we are speaking of presents many such situations: as for example the following.

1st, A canal from Ulverstone sands to Carlisle, would run nearly as follows:

	<i>Miles.</i>
Up the river Leven, from its mouth, to the lower end of Winander- meer, a little above Newby Bridge,	4
Up Winander-meer to the mouth of the river Brathey — — —	10
To Rydale Hall — — —	1
Up Rydale water to the head of Grafs-mere — — —	2
Up a brook that empties into Grafs- mere water to Townhead toll-gate,	2 $\frac{1}{4}$
	<hr/>
Carried forward	19 $\frac{1}{4}$
Through	

	<i>Miles.</i>
Brought forward, — —	19 $\frac{1}{4}$
Through Dunmail rays gap to the waters of Thirle-mere —	1
Down this brook to Thirle-mere	1 $\frac{3}{4}$
Down Thirle-mere to Smalthwaite Bridge — — — —	3
From Smalthwaite Bridge down Greata river to its junction with the Threlkeld branch of that river,	3
Up that branch by Threlkeld, Dud- dock, and Sales, to Moor End —	3
From Moor End to the Point of Partage at Mungris Dale —	2 $\frac{1}{4}$
Over that Point of Partage to Caldew river where the road to Mofsedale crosses it — — —	1
Down that river to Hesketh-new- market — — — —	5
To the mouth of Caldbeck-branch	1
To Sebergham — — —	2
Down Caldew river to the mouth of Roughton head-branch thereof	3 $\frac{3}{4}$
To Dalston — — —	2
And, down the remaining part of the river Caldew to Carlisle —	4
	<hr/>

In all 52

Which

Which may, perhaps, be safely computed to be within *one* thousand pounds per mile; if it were even necessary to cut a canal the whole length of the line.

The principal lateral cuts or branches which nature has connected with the above line of main canal (not including many small and perhaps interesting ramifications), are, 1. From Ambleside to Penrith. 2. From Ambleside to Ravenglas, by way of Conist-  
ton. 3. From Threlkeld to Kefwick, with branches from thence to Workington, Whitehaven and Ravenglas. 4. From Scales to Penrith, by way of Dacre and Dalemmain. But it will be observed, nevertheless, that each of these lateral branches runs in such a direction as to meet some other branch, by which means a line of direct communication is formed throughout the Counties of Westmoreland and Cumberland, from one extreme angle thereof to another, in almost every direction where the most interesting considerations of agriculture and commerce can be brought in contact, as it were, with each other; and to mutual and reciprocal advantage. In respect to irrigation, it is nevertheless pertinent to observe, that the system of canals herein pointed out will,  
when

when applied to my proposed national system, operate rather as catch-water drains, and general sewers, than as leading mains or conduits for supplying a superabundant resource: they will, nevertheless, in this regard contribute abundant facility to the general system; and they can be made to act alternately, for the better command and distribution of the water. They will, in this view, save an abundant expence; in as much as while they equally perform the functions of transfer, they will also convey water from the sea or lakes, to the points at which nature may have presented the least interrupted perpendicular lift or inclination, for elevating this national fluid to the back-bone of the country, and to the summit levels of the grand reservoirs.

It follows to detail the particulars of the several lateral cuts or branches of navigation of which we are speaking; and from these an approximate estimate may be obtained of the expence of extending a line of communication in any direction which is required.

1. *Canal from Ambleside to Penrith.**Miles.*

From Ambleside to the head of the				
brook which waters that place	-			$2\frac{1}{2}$
Thence to the waters of Broader	-			$1\frac{1}{2}$
Down to Broaderwater Lake	-			1
To Saint Patrick's well at the head of				
Ulles-water Lake	-	-	-	$2\frac{1}{2}$
Down Ulles-water Lake to Powley				
Bridge	-	-	-	7
To Dalemmain	-	-	-	2
To Penrith	-	-	-	$2\frac{1}{2}$
				—
			In all	19
				—

2. *Canal from Ambleside to Ravenglas,  
by way of Conniston.*

From Ambleside up the river Brathay				
to a point opposite Skelwith	-			2
Thence to the Three Tarns	-	-		2
Thence to Conniston	-	-	-	3
Offset to encompass Conniston Lake				1
From Conniston to Dunnerdale	-			$4\frac{1}{2}$
Thence to Devock Lake	-	-		3
Down that Lake	-	-	-	1
To Mulcaster	-	-	-	3
To Ravenglas	-	-	-	1
				—
			In all	$20\frac{1}{2}$



3. *Canal from Threlkeld to Kefwick; and thence to Workington, to Whitehaven, and to Ravenglas by different routes.*

This branch admits of the following divisions :

1. *From Threlkeld to Kefwick.*

	Miles.
From Threlkeld to Wescow	1
To Kefwick	2 $\frac{1}{4}$
	—
In all	3 $\frac{1}{4}$
	—

2. *From Kefwick to Workington.*

From Kefwick to Highstock Bridge	2
To Basenthwaite water	1 $\frac{1}{2}$
Down the Lake to Ouse Bridge	3
Down Derwent river to Isle	2
To Cockermouth	3
To Little Clifton	4
To Cummerton	1 $\frac{1}{2}$
To Workington harbour	3
	—
In all	20
	—

3. *From Kefwick to Wastdale-head.*

	Miles.
From Kefwick to the mouth of Grangebeck, at the head of Der- went water      —      —      —      —	3
Up Grangebeck to Styehed      —	$5\frac{1}{2}$
Thence to Wastdale-head      —      —	2
	<hr/>
In all	$10\frac{1}{2}$
	<hr/>

4. *From Wastdale-head to Whitehaven.*

From Wastdale-head to the head of Liza river      —      —      —      —	2
Down that river to the head of Enner- dale Lake      —      —      —      —	3
Down Ennerdale      —      —      —	$2\frac{1}{4}$
To Ennerdale      —      —      —      —	1
Down the river Ehen to the Bridge on the road from Ennerdale to Whitehaven      —      —      —	3
Thence to Whitehaven round the hills      —      —      —      —	$5\frac{3}{4}$
	<hr/>
In all	17
	<hr/>

5. *From*

5. *From Wastdale-head to Ravenglas.*

	Miles.
From Wastdale-head to the head of	
Waftwater Lake — — —	1
Down that Lake — — —	3
From the Lake to Wastdale —	1
Down the river Irt to Stanton —	2
Thence to Carleton Bridge —	3
Thence to Ravenglas — —	2
	<hr/>
In all	12
	<hr/>

There are also three lateral cuts, connecting various points with this first main line which extends from Ulverstone to Carlisle. They are, 1. From Conniston down the Lake to the head of Ulverstone sands. 2. From Caldbeck to Basenthwaite water; and, 3. From Orthwaite Hall to Abbey-holme.

1. *From Conniston to Ulverstone sands.*

	Miles.
From Conniston to the Hall —	1
Down the Lake to Hawthwaite —	1
	<hr/>
Carried forward	2
	<hr/>
S 3	To

				<i>Miles.</i>
Brought forward	—	—	—	2
To Peel Island	—	—	—	2
To the bottom of the Lake			—	2
Down the river Crake to Lowick	—			$1\frac{1}{2}$
To Ulverstone sands at the mouth of the river Crake	—	—	—	$2\frac{1}{2}$
				<hr/>
			In all	10
				<hr/>

*2. From Caldbeck to Bassenthwaite  
water.*

From the mouth of the Beck to the Town	—	—	—	1
To the head of that Beck	—	—		4
To Orthwaite Hall on the Point of Portage	—	—	—	2
To Bassenthwaite Hall		—	—	2
To the Lake	—	—	—	$1\frac{1}{2}$
				<hr/>
			In all	$10\frac{1}{2}$
				<hr/>

*3. From*

### 3. *From Orthwaite Hall to Abbey-holme.*

From Orthwaite Hall down the river	
Ellen to Ireby	4
From Ireby to a point in the river	
near Bolton	1
Thence across the Partage to Waver-	
ton on the river Waver	3½
Down the river to Ware Bridge	2
Thence to Abbey-holme	5
	<hr/>
In all	15½
	<hr/>

There remains, under the second general head, one grand trading line from Milnthorpe, at the head of the Lancaster fands, to Carlisle by way of Kendal and Penrith. I will not now take into the estimate any of the great leading points which are presented to the eastward of this line; such, for instance, as the communications into Lancashire, and Yorkshire, those leading towards Appleby, and from Appleby and Carlisle towards Newcastle, and into various parts of Scotland. I shall probably find some future occasion to take a distinct view

of these subjects : It will at present suffice to notice the general line.

*From Milnthorpe to Carlisle.*

	Miles.
From Dallam Tower to the mouth of the river Ken      —      —      —	2
To the upper end of Leven's Park	2
To Kendal      —      —      —      —	4
To Stavely      —      —      —      —	5
To the head of the Tarn      —      —	3
To the head of the river Ken      —	2
To the waters of Hawfwater over the Point of Partage      —      —      —	1
To the head of Hawfwater Lake      —	2
To the mouth of the Lake      —	2½
To Bampton      —      —      —      —	2
To Lowther      —      —      —      —	3
To Penrith      —      —      —      —	4
To Carlisle down the river Petteril	17
	<hr/>
In all	49½
	<hr/>

I will now proceed to recapitulate the total mileage of a system of small canal navigation, which will be amply sufficient for the improvement of the country ; as well in respect

respect to the requisite carriage of its commerce as to those primary means of improvement, which cannot fail to give it commercial wealth, through the mediums of planting, watering, manuring, fishing, and mining.

*Recapitulation.*

	<i>Miles.</i>
From Ulverstone to Carlisle	52
Ambleside to Penrith	19
Ditto to Ravenglas	$20\frac{1}{2}$
Threlkeld to Kefwick	$3\frac{1}{2}$
Kefwick to Workington	20
Ditto to Wastdale-head	$10\frac{1}{2}$
Wastdale-head to Whiteheaven	17
Ditto to Ravenglas	12
Conniston to Ulverstone sands	10
Caldbeck to Bassenthwaite water	$10\frac{1}{2}$
Orthwaite Hall to Abbey- holme	$15\frac{1}{2}$
Milnthorpe to Carlisle	$49\frac{1}{2}$
	<hr/>
Total distance	240
	<hr/>

Hence,

Hence, if we make no allowance whatever for the lakes and rivers, but suppose them to be merely feeders to the canals, and allow the very ample sum of 1000l. per mile, which (estimating all circumstances) will, I presume, be fully sufficient, we shall find 250,000l. or one quarter of a million, will be enough to lead all the improvements of agriculture and commerce into every acre of those wastes with which Cumberland and Westmoreland so greatly abound. It is unnecessary here to repeat those computations which demonstrate a powerful result. The Bishop of Landaff has thrown sufficient light on that subject; and it is anxiously to be hoped, that the means which fortune has furnished to the noble Earl of Lonsdale, and to other powerful proprietors, will be so applied as to give greater abundance to the nation, and shower the blessings of a benign influence on the crowd which may be left behind them. I will not despair of this happy result; for, in spite of the busy hints of fame, it must be indeed a sad reflection to declining years, if men were to look back on their past life without pleasure, and on their approaching dissolution with that well-described terror of the Psalmist, which would  
hide



hide its guilty head beneath the mountain chaos, rather than encounter the terrible reflection of having lived short of their power and talent to do good while they remain on earth !

#### HORTICULTURAL IRRIGATION.

In regard to the smaller ducts of irrigation, such as are adapted to horticultural application, I beg leave to insert an account of an experiment tried by me in Virginia, and communicated to Doctor Anderson for the use of his inestimable periodical work, entitled, *Recreations in Agriculture, Natural History, Arts, and Miscellaneous Literature*. I recite this with his approbation, that this little work may be in some measure enriched by practical hints, such as, I flatter myself, will apologize for repeating a few desultory communications in a more collective method.

Some years ago, during a dry summer in Virginia, I was led from observations on the parching effect of the usual mode of watering plants with a watering pot, to consider the principle of operation upon the earth and plants relatively in a vegetative state.

state. I observed, that when this method was used about sun-set, it had generally, but not always, a good effect in most kinds of soil, and produced a pleasant dew upon the grass and leaves on the following morning; but if the watering pot was too freely used during the mid-day heat, or even in the morning, it caused the earth to parch, and checked the progress of vegetation, until an annihilation of the vital principle was effected.

From an extension of this remark upon the larger scale of agriculture, which is afforded in the process of cultivating maize, or Indian corn, I am persuaded that, after plants in general have attained to a permanent radification, it is best to work the ground frequently, whether the weather be wet or dry; and, except in the case of tobacco, and such other plants as we expect profit from through the curable condition of the leaf, I think a continual working of the ground will be found a better assurance for the crops than watering only.

I was satisfied, however, that the best modes of supplying a deficiency of rain were not yet discovered. The difficulty was how to supply the regular demands of vegetative

tative succession through a drougthy season, with a justly proportioned substitute for the evaporated substance of the earth, by which it would otherwise have been succoured.

Hence (water being the natural element assigned to this purpose in its simple state) I had recourse to the experiment of a syphon made of twisted cotton.

I selected two water-melon vines near each other, in foil of the same appearance; one of them being considerably more flourishing than the other. I made my experiment upon the declining vine, by gently twisting a cotton syphon, made of candle wick, proportioned to the stem of the plant; I then elevated a pot of water above the surface of the ground, covering it from the vehement heat of the sun with a piece of plank.

Fig. 1.



Having then wetted my syphon, in order to communicate motion to the fluid upon the simple fountain principle, I tied a small stone to one end, as a weight to sink it when immersed in the water; and dropping this into the pot, I passed the other end down into the earth,

earth, by scratching the mould gently away from the root, and giving the syphon a spiral direction round it, covered lightly with replaced mould.

In a short time the earth became moderately moistened a few inches round the root of the plant, in which condition it continued through the heat of the day, without parching or scalding; the syphon supplied the demand of the plant, and no more; a cool succession took place through the effects of evaporation; and in a few days the vine became flourishing, and outgrew its neighbour.

I have repeatedly tried this experiment with good effect, and think it at least capable of extension in a garden or nursery.

Fig. 2.

*Explanation*

*Explanation of the Plates.*

Fig. 1. An earthen jar, containing water placed on a bench for the purpose of elevating the water above the plant which is to be irrigated upon the fountain principle. A twisted rope of cotton or wool, proportioned to the size of the stem, acts as a syphon.

Fig. 2. Differs from the above only in the substitution of a trough proportioned to the whole length of a bed or border; or which, if applied to agriculture, may be supposed to represent a headland ditch, or carrier trench for irrigating the whole field.

Having by this means persuaded myself that I am right in respect to the philosophical principle, it comes to be considered, whether there are any, and by what means the best plans may be adopted for rendering this experiment more general, and obtaining a greater number and variety of results from divers soils and climates; and it seems to be an interesting point of inquiry, beyond a mere horticultural application, whether this auxiliary principle may not be extended, in some shape or other, to an agricultural benefit

nefit in the mollification of harfh and thirsty lands, on the more expanded fcale of husbandry ?

A fcheme which has prefented itfelf to my imagination, but which I have never had an opportunity of reducing to practice, is, to obtain, in the firft place, a command of water upon the beft elevated level that the ground admits of ; and, purfuing this level as far as poffible with what may be termed properly, perhaps, a headland ditch, which fhould be as nearly ftagnant as the circulation of fluid will permit, I think one end of a ftraw rope, proportioned to the defign, might be immerfed in the water after the manner of my experiment, and the other be fpun out to the length of the refpective lands which were defigned for irrigation, being conducted along the ridge or higheft part thereof, by means of a ploughed trench, fo that the moiſture might ſpread itfelf each way by deſcent into the furrows, and without the risk of forming gullies, which too frequently happens in red lands, as is too generally proved in America, where the lands are but partly coated with grafs, and where they are ſubject to fudden heavy ſhowers and waſhing torrents.

This

This proposed method can, in any event, do no mischief; but it is sure to answer one good end at least in the quality of manure: for when a straw rope is once entrenched for the purposes of irrigation, it cannot possibly be converted to a more profitable use than to let it rot in the earth for a manure.

In draining, in the county of Middlesex, straw ropes, of the size of a man's leg, have been introduced into practice for the purpose of keeping open the small under drains. In this case they are found not to answer, it seems; but I conceive there is a material difference in the effect which water will produce on such a drain which is to carry off a redundancy of water, and that which is designed to supply gradually a moderate demand of moisture: the first case would, I think, be subject to wash and choak, while the latter would filter into a progressive decay, which would tend to enrich the soil.

I think the improved mole plough, which is used with six horses for forming hollow drains, might be so much farther amended, as to render it a fitting implement for the furrows of this kind of irrigation. I should advise, for this purpose, the addition of such

T

wings,

wings, as would turn one half of the sod each way, to be fixed to the hind part of the plough, leaving the mole as it is, to form a smooth round duct like a pipe. It appears to me, however, that for either this case or that of drainage, this implement might be rendered more convenient by extending the sweep of the handle down to the mole, and connecting it with the hinder part thereof by means of a thin piece of iron, fitted to the lower part of the handle with a socket, and screwed to the mole with a nut: this iron should be sharpened something like a coulter, that it may not clog the plough with the obstructing rubbish of sticks, straw, rags, &c. to which all ploughing is more or less subject. This improvement of the leverage would certainly give an easier command of the plough.

I presume the same kind of other implements will apply in trenching for irrigation, which are in use for trenching and cleansing drains: all these are to be found in Mr. Middleton's View of Middlesex, pages 291, 292, and 293. There will be found also a machine for twisting straw ropes, for a purpose very similar to that which I have suggested for irrigating farms.

As



As the expence of trenching will be nearly the same, whether it is applied to drainage or irrigation, we may take\* Mr. Middleton's rates of labour as a criterion for computation.

The prices of draining, says he, have been, for

Common drains, 20 pole 18 inches

deep, each drain - - - 0 3 0

Principal drains, 2 feet deep, of

the same length - - - 0 5 0

Burr to each score - - - 0 0 2

The labourer to find tools, and keep them in repair. Drains, on the Chace, are usually made a short pole from each other.

*Of artificial Springs, or Mediums of Filtration for culinary Purposes, White-lead Works, Paper Mills, &c. &c.*

Herein before we have considered the immense advantages arising from irrigation, in the use of water in a saturated state, for the purposes of canals, agriculture, and ma-

\* View of Middlesex, p. 293.

chinery : it is a part of our concern to discover and communicate what may appear interesting to society in their more immediate occasions of household economy ; and in such manufactures as require water in its most clear and transparent perfection. Various improvements, in these respects, have been thought of at different periods ; as for example, the filtering stone, which has been long used in the West Indies, and other hot climates ; porous jars, filtration through cloth or paper by descent, mediums of leather, pulverised glass, and other substitutes for nature, which ingenuity, rather than art, has been studious enough to render mysterious and profitable, without much regard to the health of the parties who were to drink the impregnated water, so that the secrets of the trade went far enough to please the eye and drain the pocket.

It seems to have been ultimately reserved to Mr. James Peacock, of Finsbury Square, to employ art to the laudable end of imitating and assisting nature, the only means by which men should promise themselves success in those hydraulic or hydrostatic operations which involve the great interests of whole communities.

I have

I have the pleasure of presenting a print of this useful contrivance from the proprietor's plate, and of hoping that this little work may contribute to its becoming more generally known to mankind, who have everywhere a greater interest in its efficient application, than will readily occur to those who are unaccustomed to dive into the detail of such philosophical topics; and I trust the modesty of its inventor, in respect to its non-introduction into extensive practice, before much of the patent period had expired, will be now remunerated, to amount of the vast expence and labour which he has for several years bestowed in rendering it complete, by the conviction of society, and its general introduction into public works and national improvements. The annexed plate is a description of the chamber apparatus, which is suited to the use of houses, ships, &c. within the compass of twenty guineas expence. It occupies very little more space than an ordinary filtering stone, but it is sufficient for the supply of many families; and may, of course, be applied to the joint comfort and accommodation of a neighbourhood at a very reduced proportionate charge.

A comparifon of the account given of this invention by the inventor, with that which three Captains, of high ftanding in His Majesty's navy, (to whom the fubject, has been referred from the Board of Admiralty) have certified, will not only prove that the proprietor's ftatement is free from exaggeration, but that the improvement is worthy of univerfal attention.

Mr. Peacock couches the fuperiority of his invention, over all others, in terms which will appear very modeft when contrafted with the official certificate, which follows them in ftong and recommendatory language. This machine, fays he, 1ft, accomplifhes the purpofe of complete filtration by afcent of the fluid to be purified through a medium (probably that by which nature performs the fame operation) of pure gravel, of progreffive degrees of finenefs, to the minuteft particles of fand; by which means the fouleft water or other fluid becomes perfectly freed from all its impurities, without acquiring any cupreous or other noxious mineral quality, which the pumice or other common filtering ftones are juftly fufpected to communicate.

2dly,

2dly, If, from continued use, its operation is impeded in the smallest degree, it may be completely cleansed in one minute with the utmost facility; an advantage not known to any species of filtration by descent.

3dly, Its operation is perpetual; and, without occupying more room than a large drip-stone with its apparatus, it yields a pure and constant stream of more than three hundred gallons in every twenty-four hours. This circumstance evidently puts it far above all comparison with any filter hitherto attempted.

The advantages of cleansing fluids, particularly water, says he, need not be enlarged upon. Clean linen, clear food, pure beverage, and the consequent health and comfort of the inhabitants of great cities, are materially concerned; but the seaman, who is confined in distant and hot climates to the constant use of water abounding with insects, animalcules, and a variety of impurities, which render it disgusting and frequently noxious, must acquire by this means an invaluable benefit. It is with confidence, derived from long, expensive, and repeated trials of its efficacy, that the inventor now respectfully offers this machine to the pub-

lic ; convinced that it is powerfully and effectually applicable to promote the health, the comfort, and the convenience of mankind.

Such is the statement of the man interested. I presume the following independent testimonial will support my position : “ We the undersigned do hereby certify, that in obedience to an order of Sir Peter Parker, Bart. Admiral of the White, Commander in Chief, &c. &c. &c. That we have this day been on board his Majesty’s ship Vengeance, and caused the necessary experiments to be made to ascertain the utility of a machine for purifying water by filtration.

And we give it as our mature opinion, that the machine for filtration of water fully and completely performs all that the maker promises in his descriptive pamphlet of it. And that in one instance we found its excellence to have exceeded his report of it, for we saw the filtration performed at the rate of a gallon in two minutes, or seven hundred and twenty gallons in twenty-four hours. And we beg leave to recommend it as a most useful machine, and to express our wish for its common use in the navy, particularly in long voyages,

Given



# FILTERING MACHINE.

*To face Page 281*

*Invented by James Peacock Esq."*



Given under our hands, on board the Vengeance, Spithead, July 22, 1799.

(Signed)

T. M. RUSSEL, Capt. of the Vengeance,  
EDW. BOWATER, ——— Magnificent.  
THO. LARCOM, ——— Lancaster.”

Mr. Peacock has added to this plate the following *Directions for using the Filtering Machine*.

1st, Let the handles of the cocks, A and B, be in a vertical position.

2dly, Let the upper cistern C, be supplied with turbid water, either by hand or by a ball-cock, from the main or some adjacent reservoir, &c.

3dly, The turbid water will then pass into the lower part of the filtering-chest D, and after expelling the air therefrom, by means of the pipe E, will ascend through the gravel in the said chest, and run therefrom in a purified stream into the bottom cistern F; from whence it may be drawn for use,

4thly, If it shall be intended to obtain in a large reservoir the full produce of the machine by keeping it constantly in action, a pipe must be fixed to the cistern F, within  
two

two or three inches of the top thereof, to convey the filtered water into the said reservoir.

5thly, When the operation of the machine is stopped or becomes languid, the gravel must be cleansed in the following manner, *viz.* Turn the handles of the cocks, A and B, to a horizontal position; place a bucket, &c. under the cock B; and work the pump G, by the lever h, until the water comes out nearly the colour it was of when put into the cistern C.

6thly, Then restore the handles of the cocks to their first position, and the filtration will re-commence and continue as at first, until it shall be found necessary to repeat the operation of cleansing the medium.

N. B. Whenever it may be necessary to sweeten fetid water by an admixture of powdered charcoal, this machine will be found very useful in separating the charcoal therefrom when that has had its effect.

Machines on shipboard may be filled with the turbid water, by means of a large funnel through the apperture in the top thereof, until it will wet ten inches of a rule or stick put therein.

If a piece of bunting, &c. is put over the  
funnel,

funnel, or tied to the nose of the cock by which the turbid water is introduced, it will keep out any very gross matter, and thereby prevent the pipes being clogged.

In times of severe frost, if the machine is exposed thereto, it will be proper to keep the filtering-chest empty of water, to prevent injury to the pipes, &c.

This machine is exhibited at the Surveyor's Office, Guildhall, for inspection and information. I have the satisfaction of adding that it has been highly approved by all the men of talents who have examined it:—it need not have a higher recommendation than the notice which it has received from that well-established and truly worthy rural economist Doctor Anderson, to whom I had the pleasure of shewing it. I trust a better approbation need not be looked for in the whole field of hydraulic science.

But it is from a popular and public adoption of the system into societies of several families combined, or into incorporated and national water works, that mankind may be expected to derive the extensive benefits which it is capable of administering. It is admirably adapted to prevent, in some degree, those excruciating complaints the stone  
and

and gravel. It needs but an adoption to rescue the poor and wretched from a thousand maladies which flow from the impurities with which ordinary water is impregnated; for nature supplies the source with unceasing bounty, and philosophical gravitation wants only the aid of a governed direction to convey it every where without carriage: a property which is alone and peculiarly the province of fluids.

In France we learn, that an economy in the use of water is, in some cases, a public concern in respect to agriculture; but it is an Englishman alone who turns his attention to the cleanliness of his food, and relieves himself from disease by the wholesomeness of his kitchen. He is the first to improve the means of household filtration by the contrivance of a medium which assimilates its functions to those of nature, and furnishes a portable spring which may dispense a supply as pure as crystal from the rain ponds of a desert, or the washings of a turnpike. In this happy contrivance he improves his bread, his beer, his soups, his tea, his delicacies, and his medicine: he purifies them from the filth and animalcula with which  
this

this fluid element is naturally charged ; and, thus secures his health and his longevity.

I presume that the attention of government may extend these benefits still farther, to the comfort and increase of numerous citizens. It may do still more—it may adopt a general system of national filtration, such as may amply remunerate revenue by increasing public resources and population at a very trifling rent ; and it only remains to hope that able and powerful ministers may give these pacific means a leisure moment's reflection, among those which seem to be so deeply concerned in the ways and means of carnage and systematic devastation ; and that such great national undertakings may furnish the productive means of future industry for the armies who are to return from the harvest of military laurels.

*Of the extent of Territory to be irrigated; the probable Remuneration which may be expected from Monies laid out in National Irrigation; and, of various Ways and Means which occur.*

Hitherto we have reviewed a variety of ingenious designs, both at home and abroad, executed by private individuals in some instances, and by public resources in others; and we have contemplated an infinite train of interesting consequences which have been, and are still to be, derived from works for irrigation.

This is yet, however, an infant and limited science, and it rests with us to explore a capacious field for its future expansion in considering the extent of territory which it is proposed to irrigate, the probable remuneration from monies expended in national irrigation, and various ways and means of construction which are presented.

The data which furnishes materials for computation in these respects, are—1. The state and condition of the waste and cultivated

vated lands. 2. The amount of annual income which the nation draws from their present state of improvement. 3. Those existing practical examples which afford experienced means of calculating the rational expectations of increase: and, 4. The several resources which afford capacity, labour, and pecuniary means of execution.

1. The state and condition of the waste and cultivated lands of this kingdom is now tolerably well ascertained through the medium of the agricultural papers of the nation, and the assiduity of certain members of the Board of Agriculture, who have peculiar merit in this grand establishment; and whose general accuracy is so universally admitted, that I shall think myself authorised to follow their computations for my present purpose, without regard to the mathematical corrections of Mr. Beeke; and supposing an allowance upon his calculation for the hills and dales of the country.

These investigations seem to have decided a different result indeed from that of some former geographical inquiries by Templeman and others; but if they answer Mr. Pitt's turn, they should also serve mine:— they ascertain a much greater quantity of  
land

land in the island; and they have proved, beyond a doubt, that the ne plus ultra of agricultural and mechanical perfection is but an infant, which ignorance and self-sufficiency have mistaken for a giant; whilst effeminate luxury and enervated dissipation have, with equal credulity, subscribed to the deception.

It will be acknowledged, however, that points in which the greater number of respectable inquirers agree will be the most likely to justify computations such as mine, if not to approximate truth; and on this account, as well as the superiority of the documents which they have access to, I have chosen to rely on the following statements as coming nearer to certainty than any thing else which the progress of this inquiry has determined conclusively.

\* Sir John Sinclair states the lands of England and Wales to be,

		<i>Acres.</i>
Uncultivated	— —	7,888,777
Cultivated	— —	39,027,156
		<hr/>
Total		46,915,933

\* Address concerning the inclosure of waste lands, 1795,  
P. 7.

He



He also states the lands of Scotland to stand :

			<i>Acres.</i>
Uncultivated	—	—	14,218,214
Cultivated	—	—	12,151,471
			<hr/>
Total			26,369,685

From a comparison of these statements it appears, that England contains 20,546,238 acres of land more than Scotland contains ; but that Scotland contains 6,329,437 acres more waste land than England contains, and is therefore far behind England in point of agricultural improvement and industry : for England has but little more than one sixth part of its quantity in wastes, while Scotland has far the greater proportion unimproved and lying nearly useless ; perhaps only (to use Mr. Young's idea), because the laziness of mankind is ever prompt enough to convert difficulties into impossibilities ; and some have reduced it to an ideal certainty that the higher climates of Scotland are a bar against agricultural improvements : such as the example in Forfarshire has however happily contradicted, and left us to explore the regions of chivalry in search of more solid arguments !

guments ! But Scotland has some consolations that should rouse her from lethargy and stimulate her exertion : she has more riches unimproved, and more agriculture to bestow on her sterile property than England has ; and irrigation will be found among the most powerful of her means.

If we compute the improveable probability of the waste lands of England and Wales, according to this comparative view, and by the rules which Sir John Sinclair has adopted, it will be fair and near enough our purpose to allow two thirds of the improveable prospect to Scotland, and one third thereof to this kingdom.

By this method we shall state as follows :

	<i>Acres.</i>
Lands incapable of improvement      —      —      —	333,333 $\frac{1}{3}$
Ditto fit to be planted      —	1,000,000
Ditto fit for upland pasture      —	4,666,666 $\frac{2}{3}$
Ditto fit for tillage      —      —	1,000,000
Ditto capable of water meadow	333,333 $\frac{1}{3}$
	<hr/>
Total allowance	7,333,333 $\frac{1}{3}$
	<hr/>
Actual quantity :	7,888,777
	<hr/>

Now

Now the incapable lands are considered to be of no value ; the lands fit to be planted at eight shillings per acre produce, according to the Bishop of Landaff's calculations ; the upland pasture at five shillings per acre rent, according to Sir John Sinclair ; the arable lands at ten shillings per acre rent, and the water meadow at thirty shillings per acre rent, both according to the last named author.

From hence we are enabled to make at least some kind of rough estimate of the improveable condition of annual income upon the waste lands of England and Wales alone, as follows :

Rent of upland pasture	£.1,166,666	13	4
Ditto of arable land	-	500,000	0 0
Ditto of meadows	-	500,000	0 0
		<hr/>	
		2,166,666	13 4
			<hr/>
			3

Multiply this by 3 for the annual produce, and it

gives - - - 6,500,000 0 0

Add produce of one million of acres in plantation, at 8s. -

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400,000 0 0

Prospect of annual increase £.6,900,000 0 0

Mr. Middleton has proceeded in another way to come at a similar result in respect to the arable lands of South Britain. He has attempted\* an estimate of the acres it contains, by computing the number of people employed, and their proportions of occupation in the pursuits of husbandry ; rating the inhabitants of England and Wales at eight millions.

His calculations encompass an immense field of laborious result, and valuable information. He shews the detailed state of crops and appropriations, and concludes that there are but, at most, fourteen millions of acres in aration in England and Wales ; the portions of which he rates as follows in respect to annual crops :

					<i>Acres.</i>
Wheat	—	—	—	—	3,850,000
Barley and Rye	—	—	—	—	1,050,000
Oats and Beans	—	—	—	—	3,500,000
Clover, Rye-grass, one Year's					
Ley	—	—	—	—	1,400,000
					<hr/>
Carried forward					9,800,000
					<hr/>

\* View of Middlesex, p. 482.

Turnips

		<i>Acres.</i>
Brought forward	—	9,800,000
Turnips and other roots	—	1,400,000
Fallow	— —	2,800,000
<hr/>		
Total in aration	—	14,000,000
Hop Grounds	— —	44,000
Nurfery ditto	— —	10,000
Fruit and Kitchen Gardens	—	50,000
Pleasure Grounds, the unpro- fitable Part only	— —	20,000
Pasture, Grass Lands, and Water Meadows	— —	21,300,000
Hedge Rows, Copfes, and Woods	— —	2,000,000
Ways, Waters, &c.	— —	1,603,000
<hr/>		
Cultivated	— —	39,027,000
Commons and Wastes, as stated by Sir John Sinclair, say,		7,889,000
<hr/>		
Contents of England Wales		46,916,000
<hr/>		

Which, according to Mr. Beake, (p. 9 of his Pamphlet, 1800) corresponds with Mr. Young's correction of Templeman.

	Counties.	Acres.	Bushels per Acre.	Deficiency of last Crop.
	Brought forward			
S.	Salop — —	890,000	20	6 2 1 3 in 20
	Stafford — —	810,000	25	
	Somerfet — —	1,075,000	24	
	Suffolk — —	995,000	22	8 20
	Surry — —	592,000	23	8 20
	Suffex — —	1,140,000	26	5 20
W.	Warwick — —	670,000	24	
	Westmoreland — —	510,000	20	7 20
	Wilts — —	876,000	22	
	Worcester — —	540,000	24	
Y.	York — —	3,770,000	22	8 to 10 in 20
	Total contents	40,000,000		

As I take the materials of this table from Mr. Young's recital, without knowing the principles which guided either the calculations of Doctor Halley or Mr. Houghton, whose work I have not seen, and merely suppose it to contemplate arable land, I can form no positive opinion of its accuracy. Mr. Young himself does not consider it to be wholly infallible; but it will serve the occasion of relative proportions, and, on the supposition of Doctor Halley's having either taken the horizontal admeasurement, or essayed an estimate of what he merely considered to be capable of aration, he seems to

to agree near enough with Sir John Sinclair and Mr. Middleton, to stamp their authority as a good foundation; and this basis is still farther confirmed by Mr. Pitt's adoption of this quantity, as the cultivated contents of South Britain.

Suppose, however, we take the amount of Mr. Young's statement, 40,000,000 of acres, as the probable quantity which may derive benefit from irrigation; after deducting for the quantity of water meadow, which we may suppose to be already irrigated, say 5,000,000 acres. This datum will afford a net quantity of 35,000,000 acres, which we suppose to admit of water improvements by means of actual irrigation, to be hereafter introduced. But, for calculation sake, we may say forty millions of acres, on a supposition of the waste lands adding five millions at least.

2dly. The amount of annual income which the nation draws from the present state of its artificial water ways and real estates, with their appurtenances (perhaps exclusive of internal fisheries, which may doubtless be highly improved and extended by means of national irrigation) is computed by

by Mr. Pitt, in his Report on the Income Bill, as follows :

Landlords' rents on forty mil-	£.
lions of cultivated acres,	
estimated at 12s. 6d. -	25,000,000
Tenants' profits, at 3s. 4d. -	19,000,000
Tythes - - - - -	5,000,000
Mines, navigation, and timber	3,000,000
Houses - - - - -	6,000,000
	<hr/>
Annual income -	58,000,000
	<hr/>

It will be recollected, that \* Mr. Young estimates the people of England at twelve millions. The labour of these people are the riches of the nation, properly speaking ; but, I presume, a small portion of them only can be classed as agriculturists, irrigators, and drainers : if more of them were employed in these pursuits, it would soon result in accumulated income and domestic happiness.

\* Considerations on the Question of Scarcity, 1800, p. 17.



Mr. Young\* supposes that three millions of the people of England are employed in its agricultural pursuits; and that these three millions feed ten millions from the culture of thirty millions of acres. In this ratio, seven hundred thousand persons more would cultivate the seven millions of acres of waste lands which are said to exist in England and Wales, in a more impoverished state, I apprehend, than that which nature presented them to the occupancy of man. Now if these lands were only raised to the medium produce of those cultivated lands of the kingdom which are in a state of aration, without estimating extraneous improvements, they would almost add the whole of the following sum to the annual income of the nation; for a small part indeed is at present productive:

Landlords' rents on seven mil-	£.
lions of acres brought into	
a state of culture, at 12s. 6d.	4,375,000
Tenants' profits, at $\frac{3}{4}$	- 1,093,750
Tythes, at $\frac{1}{5}$	- 875,000
<hr/>	
Increase of income from the	
culture of waste lands, with-	
out irrigation	- 6,343,750

\* Considerations on Scarcity, 1800, p. 76.

This state of culture, according to \* Mr. Young, would feed 2,333,000 people; that is, 1,630,000 persons more than what would cultivate such an extent of territory, might be fed by it at home, if the arrangements of domestic economy would make their native spot more interesting and certain to them than the inducements to emigration. But, it is presumed, that irrigation might do much in addition to this; besides, its capacity to afford immediate resources from future prospects. It is certainly a neglect that we should greatly lament, and a deficiency which we should speedily set about to remedy, when we reflect that waste lands in Westmoreland are rented at a penny an acre for the starvation of sheep †; while the attentions of agriculture, irrigation, and drainage might ameliorate their soil; coat them with warm manure; improve their climate; facilitate their conveyance; bring many new resources to market; cover them “with numerous herds and flocks; cause them to

\* See Considerations on Scarcity, &c. 1800, p. 76.

† See the Agricultural Report of Westmoreland, or the recital thereof in Sir John Sinclair's Address concerning Inclosures, 1795, p. 5.

wave with luxuriant crops of grain ;” clothe them with general verdure, and adorn their summits with stately forests.

3dly. Those existing practicable examples which afford experience and means of calculating the national expectations of increase, through the medium of irrigation alone, have been cursorily reviewed in our progress through this inquiry.

It follows, to collect a few of the facts to a focal point of recapitulation, that we may take proofs of what has been done and perfected in various instances and countries, as the best assurance of what may be performed in this by a perseverance in similar operations.

\* The richest arable land in the vale of Pia, in France, sells at 20l. 9s. 6d. per acre, if not watered; but if watered, it sells at 37l. 9s. 10d. per acre. This is a difference of 17l. 0s. 4d. per acre in the value of lands, which is to be placed solely to the credit of irrigation.

At Campan, lands, having water at command, sells at six hundred livres the journal (49l. 17s. 6d. per acre) of 700 cannes (about 19,600 feet); but not watered, from 300 to

\* See p. 211, or Young's Tour, p. 364.

400 livres. This seems to place to the credit of irrigation a sum equal to half the value when the improvements are made on the inferior priced lands of 300 livres value per journal of 700 cannes, and must be called a gain by irrigation of 24l. 18s. 9d. per acre.

At Falaise, a vale of watered meadows produces annually 3l. 10s. per acre; but we have not here the scale of comparison.

At Montelimart, an acre close to the town lets at 120 livres (6l. 2s. 6d.) per acre; but a distance off at 60 livres. This is a difference of 3l. 1s. 3d. per acre per annum, which seems to flow from irrigating the land with the liquid manure or washings of the city.

At Avignon, watered meadows sell at 76l. 10s. per acre near the city: at a distance from it they sell at 61l. 5s. per acre. This is a difference of 15l. 5s. per acre gained by irrigation.

In Provence, canals are contrived for irrigating at public expence.

Thus the averaged credits of irrigation in the several examples which we have drawn from France may be summed up as follows:

To

To the credit of irrigation, under the head of *value*;

	Value gained per Acre.
Vale of Pia - - -	£.17 0 4
Campan - - -	24 18 9
Avignon - - -	15 5 0
	<hr/>
	3   58 4 1
	<hr/>

Average in favor of irrigation,  
and gained in value per acre £.19 8 0

---

Which increased value, rated at twenty-four years purchase, gives an increased rent, flowing solely from irrigating these lands, of 16s. 2d. per acre.

To the credit of irrigation, under the head of *rent*, specifically so stated;

	Rent gained per Acre.
At Montelimart - - -	£.3 1 3
Average rent at 24 years purchase, as above - - -	0 16 2
	<hr/>
	2   3 17 5
	<hr/>

Mean gain of rent per acre by  
irrigating rich town and  
medium country lands £.1 18 8½

Brought forward	£.1	18	8½
According to Mr. Pitt's method of computing income, add,			
Tenant's profit, at 3-fourths	0	19	4¼
Tythes, at 1-fifth - -	0	7	8¼
			<hr/>
Average produce per acre, gained by irrigation -	£.3	5	9
			<hr/>

In England, we have some proofs which afford data from a few examples of poor lands raised by culture to a state of high cultivation. The lands near London were formerly nothing but moors in the neighbourhood of Finsbury, and little better in Mary-le-bone: they are now in a state of culture affording such extraordinary profits, as to render them an exception to a general rule of safe calculation; yet these lands are capable of accumulation from the helping hand of the irrigator. But we have nevertheless a few cases in the country which afford reasonable grounds for a national conclusion.

Mr. Middleton, speaking of the New River, or Sir Hugh Middleton's canal, says that

that it has probably trebled the value of many thousand acres through which it passes \*.

† The produce of meadow land in this county, says Mr. Middleton, is 10l. an acre per annum; of the arable land, in common fields, 8l.; light land inclosed, 13l. Any of these lands would produce, he says, 15l. if watered meadow §.

Say thus, meadow land	£.10	0	0
Arable - - -	8	0	0
Light inclosed - - -	13	0	0
	<hr/>		
	3		31 0 0
	<hr/>		
Mean produce per acre	£.10	10	0
	<hr/>		

This sum, taken from 15l. for watered meadow, puts 4l. 10s. per acre per annum produce to the credit side of irrigation.

\* View of Middlesex, p. 403.—† Ib. p. 317.

§ Three crops, at  $\frac{1}{2}$  load, is  $4\frac{1}{2}$  loads,

which, at 3l. only, is - - -	£.13	10	0
Other feed - - - - -	1	10	0
	<hr/>		
	£.15	0	0
	<hr/>		

X

\* Mr.

\* Mr. Templer, of Stover, in Devon, used to rent out lands at 10s. per acre; he has raised them, by means of irrigation, to 2l. and 3l. per acre. This is an increased rent of 2l. 10s. per acre per annum, and an increased produce to the credit side of irrigation of 4l. 7s. 6d. per annum.

In the county of Westmoreland, rights of common for sheep are said to be let at so low a rate as to return only a rent of 1d. per acre for the land; which, at twenty-four years purchase, makes the value of the property 2s. per acre. The farmer's rule for estimating produce on arable property would make this 3d. per acre produce: and the common right of lands in Wales, under the same predicament, at 4d. rent, would yield 1s. per acre per annum produce; yet it is doubtful whether starvation and contingencies do not undergo this. Taking thus two of the highest and two of the lowest examples in the kingdom, and supposing the latter to draw only half the benefit of improvement from irrigation that is demanded, to bring it to Mr. Pitt's medium of 24s. 4½d. per acre per annum produce throughout the kingdom,

\* See page 176.



we should meet half way between this gain of 12s.  $2\frac{1}{4}$ d. per acre produce gained by irrigating the wastes, and the highest medium of gain by irrigating which we collect from Mr. Middleton's computation of the Middlesex water meadows, compared with Mr. Templer's actual improvements in the county of Devon, made solely by means of irrigation.

In this view, the account of gain by irrigation alone, would stand as follows :

	per annum per acre produce.
Gained by irrigating Middlesex meadow - - -	£.4 10 0
Ditto, by Mr. Templer, in Devon - - -	4 7 6
	<hr/>
	2   8 17 6
	<hr/>
Highest medium produce gained per acre - - -	£.4 8 9
	<hr/>
Say thus ; highest gain by irrigation - - -	£.4 8 9
Lowest medium gain by ditto	0 12 $4\frac{1}{4}$
	<hr/>
	2   5 1 $1\frac{1}{4}$
	<hr/>
Mean gain of produce by irrigation - - -	£.2 10 $3\frac{1}{2}$

Which is yet 15s. 5d $\frac{1}{2}$ . per acre short of the gain which irrigation has actually afforded in France, according to the existing facts which are testified by Mr. Arthur Young; whose long experience, skill, and official dignity, render his evidence conclusive.

Hence we deduce a scale for ascertaining the mean value per acre of water when applied as a manure; and as this is perfectly independent of the moisture afforded during the continuance of natural showers, and should, by every possible means, be treasured up from every source, so that it may be dispensed with an uniform hand through every drougthy season, in the just proportion which the functions of vegetation requires, it of course applies to every acre in the kingdom, whether high or low, which can be brought into a state of cultivation by art.

But that I may not be complained of for exaggeration, which may very naturally be expected from men who are not accustomed to think and calculate upon a national scale, I will compute the probable gain on an equal number of acres to that of the actual cultivation which Mr. Pitt has adopted as a basis for the income tax; leaving others, however, as well as myself, to make future practicable

practicable deductions, as they may be found expedient, from this approximate datum of moderate allowance and rational possibility.

Say then that the possible gain upon forty millions of acres, contained in England and Wales, might, by means of water manure applied at suitable seasons, yield an increased produce of fifty shillings per acre, and it proves the locked-up resources of the nation to amount, in the single item of irrigation by way of manure, (without calculating its various other uses in the business of irrigation, watering cities, turning mills for a thousand kinds of labour-saving machines, feeding fish ponds, pleasure fountains, baths, moats, daries, stables, farm yards, dye houses, breweries, tan yards, &c. &c.) to the surprising sum of one hundred millions per annum.

Now suppose the national attention to be awakened to only one tenth part of this extent, or that one acre in ten were to be brought into a state of irrigation, it would greatly overgo the amount of ten millions of pounds income per annum; because, in this case, the most suitable lands for the highest improveable condition would not only be chosen for the site of operation, but the charges of elevation and distribution would

be sunk to about the level of the new river canal, and the greater proportion of the annual expence woul be absorbed in the reduction of height and mains.

It will be recollected that I have computed the annual expence of a national main, &c. at one and a half millions for an extent of fifteen hundred miles upon national account, as a mere regulating waterwork, which would at all times, I think, be sufficient to supply the surplus demanded for regulation; and, is probably a liberal allowance for disbursements, which can only be stated at an approximate computation.

Engineers will readily perceive that this idea is intended as an average which is supposed equal in expence to the detail of open and close work, small and large pipes, canals, basins, regulating locks, reservoirs, air-vessels, safety-valves, &c. which items could only be precisely ascertained by an accurate investigation, and by professional means. And it will be also understood, that I do not mean this work to interfere with individual rights, or with their works; I only mean that the nation should undertake to supply its never-failing resources to the full extent of all its demands, and to the comfort and advantage

advantage of all its subjects, who would be thus furnished with the ample means of paying a moderate rent for such an endless bounty by the profit of converting it to their various occasions.

Neither do I mean that the national purse should be touched for the means of execution. In the idea there certainly rests a public property in reserve, which is yet untouched, and may be amply used to the advantage of all men: I will not presume to dictate ways and means—I will only suggest them. I have no doubt of the national right, and I think the speculative property an object of infinite profit. The day is not far past when the cash of Amsterdam would have seen day-light upon such an occasion; and, if the national faith and safety is no ways lowered in the opinion of the commercial world, I think the conjecture would prove real that the same gold and silver which formerly shined in coin, would again make its appearance in a more profitable way than in the melting pot of a goldsmith.

Whether, however, the nation shall draw from this resource a clear annual production of five millions, or one hundred millions, seems to rest entirely in their spirit and at-

tention to the subject; for there appears to be little, if any doubt, that the single resource of irrigation is fully competent to this supply.

It will probably be objected, that I have allowed too small an estimate for annual expence. I admit it: these things are to be taken into a comparative glance, which can only be caught by the eye which is accustomed to explore them; and when it is considered how many great productive branches are untouched in this computation; (not to speak of their infinite generative relations), it will be found to end about the same mark, and will produce always in proportion to the quantum of the means that are employed.

If the nation were to take upon them the universal operation of all the water works in the kingdom, I grant it that some millions per annum must be added to the account of disbursements; but when it is considered that immense works of this nature are already in existence, and maintained at the speculative expences of individuals who reap high profit from such, it will be also seen that these would form improved branches of the national system, and that innumerable ramifications would be added throughout every

every acre of the island, promising similar gains to the speculator, annual rent to the national works, and still greater superiority to the agriculture, manufactures, and commerce of Great Britain.

When we recur to former computations on the culture of the \*larch tree, in the system of irrigation for the Northern Counties, where there is abundance of waste land, what may not be inferred from it? It affords a production of itself which co-operates to render agricultural irrigation of great and essential use. But it does more than this in respect to the larger arteries of irrigation: it facilitates the immediate construction of valuable canals, on the credit of those future productions; and it thereby opens the road to riches through the means of agricultural irrigation, sea sand, and other manures, while it every where spreads culture and population, and returns its results to the mutual advantage of water conveyance and the increase of interior wealth. Nor are these counties alone in regard to particular advantage; for most other parts of the kingdom afford some peculiar subject for facilitating the avenues to irrigation.

\* See p. 238 to 251 herein before.

at whatsoever point of the compass, afford a cheaper power to great extent ; many streams and springs lay high enough to be conducted by trenches along the sides of the hills and mountains as feeders to the national mains ; the descending rains may be collected in the same way by catch drains ; and many of the boggy summits may be so tapped and drained as to draw from their interior springs a very material supply, while much more may be raised from wells dug in elevated situations and discharged by chain pumps. Lifting wheels of various descriptions may be successively applied to return a considerable part of the descending streams into canals upon a higher level ; but, there is one existing source of considerable power which might afford a rent to the proprietors as an auxiliary to the national works : water might be conducted to every working steam engine in the kingdom, and a little additional expence might enable each to husband its spare time to the use of national irrigation.

4. The several resources which afford capacity, labour, and pecuniary means of execution, are necessarily ultimate considerations to induce us to act upon our own conviction ; and, although a non-productive stock-



stock-jobbing habit of mistaking the skin for the carcase, will be by this time expecting from me its very prompt *cui bono* of superficial arithmetic, men of deliberate reflection will very cheerfully accompany me a little farther on the road of impressive illustration and solid example; for those who undertake to think seriously for their country's good, and seek to lay a permanent basis of finance, will agree with me, that to supply an increased sum of representative revenue into the public coffers, and to lessen its demands to an equal amount by fiction, are one and the same thing in appearance; and may be ostensibly laudable; but, to furnish productive means to the nation by the culture of its latent and permanent resources, intrinsically interwoven in the web of common gain and prosperity, is a distinct consideration which leads ultimately to the death of unpopular taxation, and calls for the cooler moments of reason to explore the relative connexion of men and things, and the mutual ties of interest between government and her people.

In this progress of investigation, I always think it a duty to society to bring forward the most incontrovertible arguments which  
occur

occur to me ; and where I find ideas that have been originally the result of my own reflections, even at a very distant period back, and which prove also to have occupied the thoughts of transcendant merit and talents, I feel no inclination to mutilate the superior language in which I find them clothed, in order to reap the credit of another man's labour, or to deprive the community of those strong and impressive points which fall with double effect into the scale of their interests when they have been previously committed to paper by the pen of a more able author. In this view I have on former occasions found peculiar pleasure in surrendering the palm of distributive labour to the writings of Adam Smith, as I now have equal satisfaction in acknowledging the super-excellence of Doctor Anderson's reasoning on domestic economy, the saving of animal labour, and the multiplication of national wealth by the improvement of mechanical powers.

It will be recollected, that by way of approximate estimate through the foregoing parts of this work, I have confined my computations chiefly to the extension of a principal national artery or main for communicating

municating water from the highest summits of the country to the respective regulating basins and reservoirs, and from one reservoir to another; so that, in case of any and every emergency, a sufficient head may be given to any part which may prove deficient through casual wastage or partial drought: and all this part of the operation I have calculated, as a public right and undertaking, by the help of machinery for raising the water (even 900 feet high at the greatest possible expence) from the tides, lakes, and rivers, wheresoever any of them may afford an eligible site for transferring this inexhaustible resource of water from its natural lower level to a summit of elevation, from whence it may act in its course of descent by the mere effect of its own gravity.

It does not follow that I advise Government to be inattentive to the increase of mains, which may afterwards be required, or those more easily-commanded sources of irrigation, which the principles of natural philosophy have consigned to its pre-emptive occupancy and profit; nor would I be understood to devise the means of a progressive monopoly of this fluid element, for the exclusive purpose of public irrigation; thereby  
creating

creating endless apprehension, contest, and strife.

I would have the component capacity of the kingdom employed to husband every shower of rain and stream above the levels of the national main and its several branches, as a supply for the various ramifications of individual employment throughout the whole extent of territory; leaving every man to enjoy the benefit of his own rights, in his own way, with the least possible interference of the public works, yielding on all sides compensation for unavoidable injuries; and with this restriction only, (a construction which I apprehend to be inseparable from the essence and security of private property, and coeval with the distinction of *meum*) that he who would not employ that talent, over which the existence of social compact had given him a preference, on this implied condition, that he should so employ it, as to do neither overt nor negative injury to others, should feel the penalty of reversion to the common interest of the community.

I should in every case be less tenacious in respect to the specific application of the mean profits which might arise from lucrative works, than of that principle of general

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ral accommodation from which every member of the community derives an inherent right to the extension of expedient improvements for the public good.

In this view of the subject, it will not be supposed that I mean to shut up canals in cast iron water pipes, or to run so mad after a system of ditching and locking, as to overlook the advantages which may flow from a combination of their powers: numerous would be the instances in a national water-work, where small canals would perform the transfer of a mountainous country with great profit, and at the same time feed the ducts of agricultural irrigation; nor would the instances be less frequent where the water-pipes would form a syphon, acting from some more elevated resource to supply alternate segments of a canal of unequal heights, where the ruggedness of a country rendered an unvarying level (which ought to be our standing maxim) a downright impossibility. Often, indeed, would the case occur, in a country of this description, where an inclined plain might join the continued line of communication over a valley, where the easiest means of obtaining water would be through a combination of  
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the two powers, by laying a pipe of communication with the foundation of the rail-way.

Dr. Anderson, in his View of the Agriculture of Aberdeenshire, has done ample justice to those facilities of national transfer and locomotion which are effected by turn-pikes and canals ; nor has he omitted to intimate, in striking proofs and colours, the infinity of happy results which have everywhere arisen from a due attention to their extension into the most barren territories which were known to our ancestors, and which their darkness and prejudices had stamped with the brand of impracticability in the mist of popular persuasions.

The beautiful comparison of simple facts which Dr. Anderson has chosen, will, I hope, have a happy tendency in awaking the thoughtless from a most injurious lethargy, and in rousing the manly dignity of the antient Briton from the effeminating shackles of a fashionable insignificance. Nothing perhaps can have a more striking effect upon a popular mind, which seems to have nearly lost itself in the labyrinth of operas, routs, galas, and nightly theatres, than the cherishing prospect it must behold  
itself

itself extricated to the enjoyment of, in contemplating the progress of arts from the dawn of untutored invention; the progress of science from a rude hieroglyphic; the progress of agriculture and commerce through the dreary waste, the uncultivated desert, the trackless course, the cheering footpath, the accommodating cartway, the facilitating turnpike road, and the still more wonderfully powerful canal. It is to these indeed, and to the inventive genius of those who contrive labour-saving machines, that mankind owe most of their comforts and treasure; that commerce and navigation owe their prosperity, and cities their astonishing grandeur!—But it is time to recur to plain, simple facts, which need neither type nor flower of illustration:

\* “The object of roads,” says Dr. Anderson, “can never be brought too often under view where improvements are proposed, because without having good roads, every exertion in other respects must be clogged with difficulties that are insurmountable, and no progress can ever be made.

\* Report to the Board of Agriculture on the Rural Economy of Aberdeenshire, in 1794, p. 219.

“I am old enough,” continues the Doctor, “to remember the first turnpike act that was obtained for Scotland; and I recollect the time when a carriage of any sort upon wheels, on the road between Glasgow and Edinburgh, was such a rarity, that the whole people in a village went out to look at it, and the children would have followed it for a mile; and now the intercourse between these two places along the same road is such, that carriages pass every minute. What has been the consequence of it? The produce of every farm can be carried to market at one-tenth part of the price they formerly could be. Manures can be obtained in great quantities to many farms eight or ten miles from Edinburgh, where not an ounce could ever have been brought. A spirited cultivation of the ground has taken place instead of the languid torpor of former times: the fields are much better managed than formerly, with less than half the beasts of labour. The rent of land is nearly trebled, and the tenants are universally more wealthy in every respect than before. At the distance of twenty miles or more from Edinburgh, where, by reason of the badness of the climate, the poorness of the soil, and the



the want of markets, the grounds were as effectually locked up from the plough as if they had been bound up by an everlasting frost: a market being now brought to their doors for corn and hay to supply the numerous horses, and other kinds of necessaries for the people who travel the road, provisions for those who afford them accommodation, and for the numerous artificers who are wanted to supply the necessaries they stand in need of, and the people who are constantly employed in making roads, repairing carriages, building houses, and other necessary operations, means have been put into the hands of the occupiers to cultivate their grounds; in consequence of which the unfavourableness of the climate has been surmounted, the barrenness of the soil corrected, and extensive fields are now under cultivation, and bearing abundant crops, which, if the former state of the roads had continued, must have remained barren heaths to the end of time.

The people in every country district, where turnpikes have not been erected, look upon them with some degree of aversion, as the money paid at these toll bars appears to be a burden on those who pay it: and those

in towns are still more outrageous against it, because they think the money there paid must be added to the price of the commodities they are to consume, and must ultimately land upon them. They do not advert to the diminished price of carriage, which will be a consequence of these turnpikes, and which bears no proportion to the toll. For example, at the period alluded to, all coals were brought into Edinburgh on horses' backs: a horse-load at that time was two hundred weight. All coals are now brought in carts, and there are some of these coal-drivers who now bring twenty-eight hundred weight in a cart drawn by one horse: for this he pays twopence halfpenny of toll; so that he brings what would have employed twelve horses and six men for twopence halfpenny. The saving here is so enormous, that if it had been mentioned *a priori*, it would have been declared to be impossible; but the facts are incontestible; and though they could not be foreseen, they are now felt on the universal increased prosperity of every class of people; many of whom, while they feel its influence, are unable to trace the beneficent cause from whence it flows."

I shall

I shall pay some degree of respect to the ways and means which have occurred to this inestimable and accurate observer in the affairs of rural economy, in regard to what concerns the construction of turnpike roads ; for every saving in these concerns will apply still more forcible to the construction of canals, which are ever to be considered as a superior degree of public ways, rendered more infinitely competent to all great operations in conveying heavy burdens (even in a fifty-fold degree) at a very reduced expence, without considering how much more money is required to amend the daily cutting of carriage wheels ; or computing, on the other hand, the various items of irrigation to which this very great facility of conveyance will convert every surplus drop of water, without incurring an additional charge. Yet it is wonderful to observe the very general aversion of that commonality, who are the most burdened of any persons for want of such, to an extension of these great national improvements on such productive principles, which administer comfort and plenty to the most needy at reduced prices, in lieu of poverty and extortion.

“ There is no popular prejudice I ever met with,” says this same author\*, “ that is so unreasonable as that which prevails against turnpikes. In most other cases the people are anxious to throw all public burdens upon the rich rather than the poor ; but the case is directly reversed in this instance. The roads are all made where no turnpikes exist, by the labour of the poor, for which they receive no payment ; many of whom have neither horses nor carriages ever to travel on these roads : but the rich, in consequence of that labour, are enabled to loll in their carriages at their ease ; and while they are thus cutting up the roads, contribute nothing to put them in repair. A turnpike act, (and consequently a canal act, for that is to be considered as a superior species of turnpike) which subjects these persons and others who are to use the roads, to a tax to put them into repair, is obviously the most equitable plan for making the roads that ever could be devised, and shifts the burden, in the first instance, from the shoulders of the poor to those of the wealthy. One would imagine

\* Rural Econ. of Aberd. p. 132.

that

that a turnpike act, on this principle, ought to be universally a very popular thing."

Dr. Anderson recommends, as a mode of expediting these great public undertakings, that a sufficient sum of money should be borrowed, upon a mortgage of the premises, to complete the works intended at once; to begin nearest to the town, or point of production; to suffer no money to be diverted from the purpose designed; and that if any difficulty arises in borrowing the money, the gentlemen of the district through which a line of communication is to extend, would do well to consult on the risk and propriety of warranting the tolls to the amount of the interest of the money borrowed, by the joint security of all the persons interested in such line; any deficiency, in case of necessity, to be assessed upon each individual, so binding themselves in proportion to their valued rent: they themselves, in that case, to become creditors on the undertaking, to the amount of such advances, if ever they should happen, to be paid when the state of the tolls permitted it. The reasoning which applies to this kind of security, with the advantages to be expected from it, are both of them obvious.

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The following ingenious remarks, on the importance of keeping a level in the construction of roads, are made by the same author\*:

“ In every line of a turnpike road the strictest attention should be paid, so to line out that road, as to keep it as nearly upon a level plane as possible ; and that in laying out these roads, every other consideration should be made to give way to this one. The inconveniences that result from pulls on a road begin already to be felt ; and every day's experience will tend to put this article in a more and more conspicuous point of view. At present, every one feels the necessity of avoiding great pulls, but few have their minds sufficiently impressed with a conviction of the infinite importance of small pulls. When they consider, that if the roads be once made firm and good, so as to admit of carriages going at all seasons of the year with a single horse only, that horse may go with ease upon a level road with a load, which he could not, without overstraining himself, move at all up an acclivity, even of one inch in a yard : it must follow, that if such acclivities frequently oc-

\* Rural Econ. of Aberd. p. 134.

cur, an universal diminution of several hundred weight on each load that is to be carried along them must take place; and if we were to attempt to make a computation of the loss that would be thus sustained by the public, it would amount to something that approaches so near to infinity, as to appear incredible. For it is to be remarked, this loss should be made to comprehend, not only the amount of carriage of the surplus quantity on what is actually transported, but also the total value of things which might have been carried, and which, because of this additional expence, must be allowed to go to absolute waste where they now are: for there are many articles which might be useful in arts and commerce, that might find a very extensive sale, if they could be afforded at a specified price, but which, if raised the merest trifle above that, can never find a purchaser at all. I must therefore beg leave to repeat it, that this is a matter of such great importance, that almost no other consideration should stand in its way."

After making these and similar interesting remarks, the Doctor adds, "Every argument that can be used for the making roads, applies with still greater force to the making  
of

navigable canals, wherever the situation is such as to admit of them \*."

But he wholly depreciates the mode which hath hitherto been adopted for raising the funds that are to be employed for constructing canals, as the worst that can possibly be conceived, as being uneconomical, unnecessarily burdensome to the public, as well as its being calculated to defeat the intent, to ruin the first adventurers, to promote a spirit of gambling and speculation, which ultimately terminates to the advantage of unconcerned purchasers, who have avoided the burden of the undertaking, while others have sunk under the weight of procrastination and ill-managed difficulties. In support of this opinion, he gives two striking instances: the first in the case of the Forth and Clyde canal, which, after a long suspension of competent remuneration, returned thirty per cent. upon the very shares which had been sold out through distress; and the other in the case of an old canal in Yorkshire, which returned 500l. per annum to the speculative purchaser of shares, which cost

\* Rural Econ. of Aberd. p. 136.



only 50*l.* under similar embarrassments of depreciation.

These facts, he concludes, need only to be stated to shew that the whole system is radically defective; and not only is productive of private distress, but is also subversive of the interests of commerce, for the benefits of which they were formed; and that, therefore, it ought to be departed from.

There is, however, one plan which strikes Doctor Anderson's mind as an effective one, through the happiest result of experience in several similar cases in this kingdom\*. "It is simply," he says, "to raise the money for making canals, which are literally public roads, after the same plan as for making turnpike roads:—that of mortgaging the toll duties to be levied from them to procure money for making them.

"There is only," he continues, "this difference between roads and canals, that a

\* Two cases are cited in support of this plan, *viz.* the building the bridge of Perth with money borrowed upon the tolls, which was soon remunerated and free; and the light-house built by an individual upon the Isle of May, which returned to Miss Scott a perpetual income of 1500*l.* per annum, likely to grow into a ten-fold tax. See *Rur. Econ. of Aberd.* p. 138.

canal can in almost every case be made at a much smaller expence than a turnpike road, capable of transporting the same quantity of goods, and can be kept in repair at an infinitely smaller expence: of course the very moderate tolls that need to be levied at first, will afford a more undeniable security to the lender."

It is not easy to impress the common run of the people with the idea of creating necessities, conveniencies, and even luxuries, by a little degree of contrivance; yet this is a position which is easily conceived by the analysing eye. If the state of roads and navigation had been left wholly to the bounties of nature, without the improvement of art, the citizens of London would never have enjoyed that solid and accommodating pavement, which must unavoidably have remained a dead subject matter in Scotland; nor would the latter have received the reciprocated advantage which has remunerated a prosperous condition to a place so remote from the metropolis. If roads and canals had not arrived to their present state of improvement, where would have been the stint of commerce and navigation, or the pleasures of a Bond-street lounge? Yet these facilities

ties are in a mere state of infancy, and afford abundant and wonderful resources in their progress towards perfection. If such a fanciful thing exists as the Philosopher's stone, it seems only to be found by the civil engineer in the digging of canals, constructing of roads and water works, and extending the unlimited power of mechanics to the reduction of animal labour: there is scarce indeed an end which man can wish for, but what this most honourable science can facilitate; even the dust of the turnpike roads may be conquered for a very insignificant expence, (very far short of the charge of stupid watering carts); and from the great extent of space which is hourly occupied by the business and pleasures of the kingdom, the accumulation of revenue might be rendered very perceptible in its aggregate returns from the most populous highways. If an exemption from the choakings and blindings of dust, still more perceptible in its effect upon the fine four-footed animals which are daily driven in speed, and very speedily reduced by thirst and perspiration, was only farmed of government for the carriages and horses employed in pleasure, it would afford a very respectable resource; while

while it would prove a wonderful saving to proprietors, and an interesting acquisition of public wealth and strength.

Resuming the subject of roads and canals, with great truth it is said by Doctor Anderson, that \*there is a maximum in all cases of the kind—a line to which you can just come, and no farther. Within that line is the sphere of possible cultivation: beyond it every improvement must be for ever stopped. Now no one can say where that line may be placed for particular articles; of course no one can say, but he himself may be affected somehow or other in a way that he cannot just now perceive. Let people consider what a mortifying thing it would be to have themselves placed beyond that line, when, by a little forecast on their part, they might have been far within it. There are thousands of bulky articles of small value, which, if brought within reach of market, might prove of inestimable value; not so much by the absolute money they bring, as by enabling the owners to bring lime, and other articles of great utility, as a return carriage which could not otherwise have been obtained.

\* Rural Econ. of Aberd. p. 140.

To apply then the inferences of this very able economic observer to the vast interests of England and Wales, it is now, and always, the appointed time to look forwards. The state of Westmoreland (where the rights of common for sheep are said to fetch a rent of a penny per acre), may be the means of fertilizing extensive districts if the means of transfer can be so facilitated as to carry that state to market with profit. The woods belonging to every gentleman in the county, if the lake navigations shall be improved and canals shall be extended clear of needless tolls, may be rendered the means of improving their estates, and of planting successive woods upon suitable wastes. Clay or stones of certain descriptions may possibly answer the same purpose; and, perhaps, mines may be farther discovered in the search which will be made for these. The sand and manure of the sea coasts may be reciprocated in return, and by this means the cold and clayey soils may be ameliorated, after its bogs have been drained and rendered arable by the industry of national irrigation. In short no one can say what a variety of articles may in future be discovered among those bleak and heathy wilds of the Northern Counties,

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which

which prejudice and inexperience have deemed as impracticable in our day as the wonderful effects of the steam engine would have been declared in the most lucid days of our ancestors, or the discovery of a western world before the enterprize of a Columbus.

Among the various obstacles which impede the progress of success in the operation of canals, and which diminish the profits which are expected from them, Doctor Anderson, very justly I think, reprehends the rage for extravagantly magnificent things, greatly disproportioned to the wants and to the present circumstances of the country\*.

“When a great deal of money,” says he, “is expended on a canal, through which there cannot for many years be much commerce, the pontage dues are necessarily so high as to repress the trade upon it to an astonishing degree. Even at present the expence of pontage, on the canal from the Forth to Glasgow, is so high, that nearly one half of the goods that go from Edinburgh to Glasgow can be sent cheaper by land. Had it been a small canal, on which the pontage would not necessarily have

\* Rural Econ. of Aberd. p. 140.

amounted to one fourth part of that per ton, the intercourse upon it would have been a hundred times greater; and this extension of intercourse would have enabled them to have lowered it still much farther than that.

Better therefore to make a small canal originally that shall be proportioned to the present wants of the country, and when the intercourse becomes so great as to require a larger one to make the canal then larger, than to expend at the first a great deal of useless money, which, instead of benefiting, must tend to prove hurtful to commerce."

I think, however, we may now venture to prognosticate, that if such counties as Westmoreland, Cumberland, and a great part of Yorkshire and Lancashire, ever enter upon a system of small canals, as they certainly are interested to do, they will never see the day when they would wish to enlarge them, howsoever paradoxical it may seem to them at present should they be told that a small canal system will transfer more goods than a large one, although the expence of construction may not perhaps exceed a third or fourth part of the former, averaging all situations and circumstances.

\* “The public have been precluded from receiving the benefit of canals in many cases,” adds the Doctor, “from the circumstance of our having universally adopted the plan of lowering and elevating boats by means of water-locks alone, which, by requiring such a vast supply of water, renders it impossible to have a canal at all in many cases where they would have been otherwise practicable, and in all cases greatly augments the expence that would be necessary if these could be dispensed with; besides retarding the intercourse by reason of the numerous stoppages they occasion; for as no water-lock can conveniently be made to lower at once above six or eight feet, where a rise is considerable, they must occasion frequent stoppages; whereas, in the other way, it would make little difference to lower eighty feet or eight. But I must not now stop,” he observes, “to detail the benefits that would in some cases be derived from this circumstance. These would sometimes approach to infinity.

“We have farther,” he says, “been in a yet more eminent degree deprived of the

\* Rural Econ. of Aberd. p. 141.



benefits of water carriage, in innumerable cases, from the circumstance of our never having attended to the benefits that might be derived from the conveying water canals on a level through a great extent of country, as may often be done at a very small expence, along the sides of low ranges of rising grounds, for very great distances through corn countries, which would not only shorten the distance of land carriage of corn, &c. to market, even where the canal could not go the whole way, but also would, in innumerable cases, facilitate the conveyance of lime and other manures from one part of the country to another.

\* Were a method devised for conveying loaded boats from one canal into another, without the aid of water locks—and were canals made of a small size, and consequently at a cheap rate—and was the necessary attention bestowed to carry every canal as far as it possibly could go upon the same level through the country in all directions, there is not a doubt but that goods could thus be conveyed at a small expence by water car-

\* See Political Economy of Inland Navigation, &c, p. 80, 91, 95, 101, 107, 110, 113.

riage to and from almost every corn farm in this extensive district \*.

“ To obtain all these benefits,” rejoins this inestimable friend of mankind, “ I would propose that every canal should be considered precisely as a public road, and put under the management of the Commissioners of Supply in every district, exactly as the turnpike roads are at present. After proper surveys have been made, and the practicability of making a canal in any particular district ascertained, an act of Parliament should be obtained for making such or such a canal, and for levying tolls, to be specified in the act ; the whole proceeds of which should be applied, in the first place, for the payment of the sums expended on making the canal, with interest till paid up ; and upholding the canal itself, and nothing else, and extending it farther, if judged necessary ; and after this money was paid up, the tolls on that canal to be lowered, so as to amount to no more than is necessary for keeping it in thorough repair.

For the purposes of internal commerce, it does not seem necessary ever to have a boat

\* Aberdeen.

wider, in any case, than four feet; nor the draught of water above two or three feet; for as the length of the boat may be indefinite, it is easy to proportion that to the burden intended: of course, where the circumstances are such, as that the boats will not be very frequently passing each other, a width of five feet, and a depth of two feet and a half, or three feet at most, are sufficient. Where canals of this small size are adopted, a niche may be made at the side at every quarter or half mile or so, sufficient to receive one boat until another passes, where they chance to meet.

I am aware of the objection that will here occur, on account of the great resistance that would be made to boats passing in a canal, with so little vacant space on each side of the boat; but as every person, in the least acquainted with the laws of hydrostatics, knows that the resistance from the water would be equally diminished if there was one inch depth of water only on the surface, as if there were a thousand fathoms deep, this objection may be entirely obviated by laying the earth that comes out of the canal five or six feet back from its edge, so as to allow the water there to flow over the origi-

nal surface of the ground. By this means, the breadth of canal wanted is obtained without any expence; so that to dig a deep canal under the pretext of widening it, for the purpose of removing the resistance, is a mere useless expenditure of money.

“ As it must happen, however, that by thus widening the canal, the evaporation will be thereby augmented; to guard against this inconvenience, it will be always adviseable to make the towing path, if possible, on the North-east side\* of the canal, and to plant the opposite bank all along close with willows, which by their shade will screen the canal from the influence of the sun, and by their shelter defend it from the drying effects of the South-west winds which so much prevail in this climate during the summer season,

“ Near the sea, or any great town, where the intercourse must be more frequent, the breadth of the canal may be nine or ten feet, so that two boats may pass each other everywhere, having the same depth as before.

“ A canal on this plan would in some measure resemble a river. The principal

\* The prevalency of winds vary, in different places.

trunk should be of the larger size; the lesser branches, that went off to particular places, would be of the smaller. The expence of making a canal of this kind would be very small, for little earth would require to be removed. Were a ditch, five feet wide and two feet deep, to be dug out of the solid to the whole depth, it could, on an average, be dug at the expence of\* sixpence a yard; but when it is considered, that by throwing the earth principally to the lower side, the water may be raised above the level of the ground, it will not require to be cast so deep, and of course the expence of making it would be lessened. This will be a large allowance for the small canals; and one shilling per yard a full allowance for the larger, not including the expences of locks, aqueduct-bridges, &c. This is upon the supposition that they are to be carried upon the level†, following the form of the ground wherever it may lead to; but where hollows are to be crossed, which ought never to be done but in cases of ex-

\* Prices are local: this is at Aberdeen in Scotland.  
W. T.

† This general rule will meet many exceptions.  
p. 22, one in Leach, p. 107. Liskeard canal.

treme necessity, an additional expence will there be incurred, as well as for aqueduct bridges, where these become necessary. These expensive works can only become requisite, however, on the larger branches; the smaller ramifications which fall into these can scarcely ever require the aid of such expensive erections.

As to bridges for allowing the water to pass under the canal, unless where the stream is considerable, this will not be necessary; for by making the towing path always on the upper side of the ditch, and leaving at proper places a long level on the lower bank, at the same height it is ever meant to rise to, whenever superfluous water, from transient rain or other causes, came into it, this would flow over these long levels with a calm silence that would never be felt.

“ Were a trunk canal of this sort carried along the rivers of Aberdeenshire,” concludes the Doctor, “ the Dee alone excepted, which is too rapid, and too much confined on each side by mountains, easily to admit of it, and were lesser canals branched off from it at every rivulet that flowed to any distance through a level part of the country, its improvement would be wonderfully facilitated; and

and when the smallness of the expence of such erections is considered, and when it is also adverted to, that by this means the expence of highways would be considerably diminished by removing from them all weighty carriages, this will not appear to be a difficult enterprize; for it will require much less money to make one of these canals than a turnpike road of the same length; and the keeping it in repair, when once made, would be, in comparison of a road, next to nothing."

The Doctor next proceeds to exemplification of the principles which we have been tracing; but, as an examination of these would require a detail knowledge of the country, I shall content myself with noticing a few striking particulars which may be of general use. He points out the various levels and places proper for branches and ramifications diverging into every quarter of the country, and says that nothing could be better devised for giving a perfect idea of the plan which ought to be adopted for forming canals of the kind he alludes to, than the parallel roads in Glenroy, near Fort William.

\* " These

\* “These roads,” he says, “are carried forward along the sides of the hills, in a direction everywhere perfectly horizontal. Wherever they come to a cavity in the hill, they there bend inwards till they find the natural level; and where they come to a river, instead of sinking down to the level of its bottom, or requiring to have a bridge directly across it to raise the ground to its proper level, they turn up the bank of the river, keeping still the horizontal direction, till they thus gradually reach the bottom of the stream; when crossing it, and altering their direction once more, they pursue the course of the stream on the opposite bank till they reach the strath, when they proceed forward in the same horizontal direction as before.

From this unaccountable work of a barbarous age, we may be taught one important lesson in regard to the conducting of canals, which seems never yet to have been adverted to; viz. that in many cases it may be practicable to carry forward a canal at less expence through a country intermixed

\* Rural Econ. of Aberd. p. 146.



with long ridges of hills, than in those that are low, and in general of a smooth surface; for even where the declivity of the rivers are considerable, if the hills are not discontinued, a canal upon the same level may be carried forward very far, and cannot be interrupted by the lesser streams that fall into the vale, because the declivity of these rills is so great, that the canal requires to be carried but a very short way out of its direct course, before it finds its level across it, so as to avoid the necessity of having aqueduct bridges there; whereas, in more level countries, these rivers often flow through a long course of level ground, which cannot be crossed without either locking down on each side of it, or turning out of the way a great many miles before you can cross the river upon the original level. Many benefits, however, would be derived to the country, were the conductors of canals to be in general much more parsimonious of their locks than they usually are, so as to endeavour to try, in every case of this kind, to cross the interrupting vale and stream upon the natural level of the canal.

It would be improper to enter in this place into farther particulars on this head, or to  
enlarge

enlarge on the benefits the country would derive from the opening up of a communication of this sort, which are indeed sufficiently obvious. The difficulty will be to persuade most men that a thing which is represented as so easy, can in fact be literally practicable; because they think if it had been practicable it would have been long ago adopted. To this objection I shall make no answer; but beg leave only to state the following fact.

After tolerable roads were made through most parts of Scotland, so as to admit of their having free intercourse with other places, Archibald Duke of Argyle and other gentlemen of that country were desirous to open a communication between the peninsula of Cantyre and the other parts of Argyleshire, which was disjoined from them by a rugged ridge of very high hills between which no passage could be found. Many surveyors were sent to explore this rugged region; but all of them returned with the most discouraging report. Most of them said that it was not possible to make a passible road at any expence for about seven miles of that district. Others reported that it might perhaps be possible; but that at the lowest

lowest estimate which could be made the expence would exceed thirty thousand pounds. This was a sum so enormous that the idea of executing it was for the time abandoned. Still however the necessity of having such a communication occurred, and it became an endless subject of conversation at the county meetings. At length one gentleman observed, it could never be done if they did nothing but talk about it; and proposed that they should try to do something. It was immediately resolved to open a voluntary subscription to make at least a beginning, and try what could be done. Fifteen hundred and odd pounds were subscribed at the meeting, and a committee was appointed to see the money expended, and to make a report how far it went. The work was begun and carried on with alacrity while the money lasted; and, to the perfect astonishment of the next meeting, they laid their report before it, when it appeared that the whole of the road was completed in the most perfect manner, and better than one hundred pounds of the money remained at the disposal of the meeting. If, before this trial was made, any person in the county had said it might be effected for fourteen hundred pounds,

1 pounds,

pounds, he would have been laughed at for advancing such an absurd opinion."

A similar thing happened within my knowledge at Lumbeston in North Carolina. Near this place, upon Drowning Creek, there is a branch of that creek called the faddle-tree swamp which is narrow and passable at its junction with the creek, but widens considerably and is difficult to pass on account of the mire and thickets, till it extends some distance up into the neighbourhood. The path which crosses the mouth of the swamp is so near the bank of the creek, that in the time of freshes, or land floods, it is greatly inundated; and as people often encountered the risk of crossing this place in preference to going a round-about way, several persons had been drowned. I observed, from the formation of the land, about a bow shot from this place, that notwithstanding the impervious aspect of the thicket, there appeared to be there a more solid foundation and no great distance through the swampy part; and I proposed to fall upon some plan or other to open a new crossing place; but this was deemed to be, if not wholly impracticable, at least a very difficult undertaking. I at length proposed that

that voluntary working parties of the neighbourhood should encounter it, by way of a frolic, on Saturday afternoons, till we either succeeded or were tired of the experiment; and that *I* would furnish rum. This last proposition had sufficient charms to set half a dozen axes at work; and we not only reduced the job under a day's work, but opened a cart-way through a better part of the woods for at least half a mile beyond it.

I recite these cases to shew how frequently that bugbear, ideal impossibility, deters men from undertakings of the highest importance to themselves and country, when the only great difficulty is to set about the business with that true spirit and energy which is competent to remove every obstacle that may be impeded.

*Of the Ways and Means for constructing  
Works for National Irrigation.*

I feel a delicacy in the task of digesting a plan for carrying into execution the various works of national benefit which I have suggested; not, however, that I perceive any

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great difficulty in the business, but it is enough that I am not officially employed.

Hints may, nevertheless, be of use to those who are more immediately concerned; because they may call to their recollection both variety of methods, and choice of subject matter to be acted on.

In the progress of this work, under the head of *Irrigation of the Northern Counties*, I have suggested ways and means of operation which I think government may use to very great advantage, whether it is viewed as a public or private undertaking. In the one case they will hold the agency and profit in their own hands, by means of their officers; and in the other, they may either reserve a certain portion, or moiety perhaps, of the interest which shall annually arise, or they may sell or farm out the privilege of national irrigation upon speculation, on the faith of a parliamentary guarantee. This, I apprehend, without infringing private rights of property, may be legally granted for the considerations of accumulating revenue and national strength.

Doctor Anderson seems to object to any other mode of extending canals than that which has been adopted for the support of  
turnpikes.

turnpikes. His motive is certainly a laudable one; and it should heartily meet my approbation if it were practicable to carry his plan into execution: the question seems to rest chiefly in the spirit of the times, and will of men in power.

Private means are often adequate to very great undertakings; but there are many instances where success must depend entirely on a combination of powers and circumstances, or where the supreme intervention of the community becomes essential. In favour of national irrigation, the interruption which small possessions might impede in the way of system, and of improvements of the greatest consequence to all, is a strong argument; for it will be always found, in practice, that one obstinate man may do a great deal of mischief, or prevent a great deal of good to his neighbours; and that if men are not previously bound, by their joint agreement, to take a fairly-assessed compensation for unavoidable injury to individuals, (a method which I would always recommend in the extension of water works, roads, and canals), the generality are prompt to stand out for an extortionate remuneration which procrastinates the business intended; and if it so happens

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pens that the law has been silent on this point, the undertaking must either submit to a gross imposition or stand suspended; although the refusing party is aware that his estate must become eventually improved in value by the very completion which he withholds his consent from.

These are circumstances, among others, which seem to indicate the propriety of undertaking works of national irrigation on the strength of the public purse, and returning the annual profits by a rent stipulated for the respective quantum of benefit, without intruding the odious term *taxation* upon the ear which feels sorely galled.

In executing the work, I presume, if undertaken for public account and risk, there would be no impropriety in employing the soldiery who may have leisure for such labour. The Spanish soldiers avail themselves of the king's extra pay for their labour in works of public utility, and this is deemed highly honourable. It fits them moreover for the duties of their profession; and thus familiarizes them to many fatigues of a campaign, which are rendered lighter by habits of industry and the acquirement of professional knowledge. In respect to the  
2 soldiery



foldiery who return on the eve of peace, it would be anticipating a means of subsistence; and an occupation of more honour and profit than was ever drawn from the source of robbery: above all, it cannot be less honourable to work for the king than for his subjects, and I am persuaded that patriotic attachments and zeal for the public interest would stimulate a soldier to much national saving.

The ordinary ways and means of constructing canals, are too generally understood to need my feeble explanation; I only lament that so little attention is paid to the expansive capacity of finance, and that mankind are so exceedingly tenacious of the treasure in the napkin. It might be greatly accumulated by good and faithful stewards of the Lord's interest! but it is not my province to criticise the non-feasance of social duties.

There seems to be one general point in which all the respectable writers on ways and means to increase the public revenue seem to agree—The public demands should contemplate the least possible inconvenience to the pockets of individuals; but, wherever it becomes necessary that these should be touched, let the reciprocity be made as

visible as possible; for it may be observed that right demands taxation, but prudence sends conciliation in the company of right. Mr. Middleton and Doctor Anderson prefer the turnpike system: it carries fairness on the face of it, because mankind see the benefits they are paying for. Others prefer mortgaging the premises for the means of execution, until the tolls shall redeem the expences and set the people free. Both, I apprehend, attain the same end in respect to the ultimate result: the one strengthens the national resources by its voluntary encouragements to a national industry which accumulates public wealth and strength for a lateral responsibility; and the other demands remuneration for a visible accommodation.

The only difficulty lies in the present state of public necessity; Government wants money to enable her protection to society, and the question is, how the saddle will gall the least. I have suggested the principles of foreign and domestic popular confidence which occurred to me in my preliminary observations; and if I were a rich man, residing even in Paris, or in any other foreign land, I should have no hesitation in speculating

lating upon so safe a subject. We are not, however, without numerous precedents for the model of government loans upon the credit of their future prospects; and, if I were so fortunate as to be a money-lender, I would certainly solicit this security in preference to any beyond the channel. I shall only offer one resource more, which attaches to the condition of human depravity.

*Hints towards employing the vagrant and disorderly Classes of the Community in Works of National Irrigation, Inland Navigation, and Drainage; as a remuneration to Society for the Depredations they may have committed.*

I suggest the following ideas, with hopes that they may call the attention of authority to the use which they may be of in the police of the metropolis more particularly, in regard to a compulsive application of the time of vagrants and petit criminals to a new species of industry in the item of irrigation; while means may be thereby obtained for the voluntary employment of the industrious poor in co-operative occupations.

I apprehend no man can have passed the streets of London without being more or less incommoded by impertinent importunities from some description or other of that disorderly multitude denominated beggars ; and I am persuaded it would require nice judgment to penetrate the various deceptions that assimilate the impostor to the real object of charity, if the benevolent founders of numerous public institutions had not so greatly removed the propriety of giving alms to so promiscuous a description of people.

Let us inquire then for a moment, whether that benevolent spirit of the English nation, which has been the boast of ages past, has produced a good or evil in this respect ? Or, whether by the lure of mistaken gratuities to innate sloth, we do not bring about the very ends we incline to prevent ; and, whether we do not thus induce many professional impositions which it should be our study to avert by providing means of subsistence for the worthy indigent, and compulsion for the useless or villainous.

That we may be better enabled to keep in view such persons as this kind of inquiry should contemplate, we cannot refer to a better guide than that which has influenced legislative

legislative decisions through successive ages, and afforded scope for the notice of that learned judge, Sir William Blackstone, in his excellent Commentaries, under the head of *Offences against Public Economy*, vol. iv. p. 165, to 169.

Such a history of the rise and progress of nuisances and petty crimes against public economy, as that which the judge has been at the pains to trace from early dates, will not only be found somewhat instructive to many who are little in the habit of legal inquiries, but it may afford a scope of reflection to the curious mind, which will amply repay the trouble of referring to the subject; and it will in some measure prepare us for a more ready distinction of the several objects which the classification of misfeasance seems to have fitted for the present occasion.

When we pass from the several periods which this very able judge has enumerated in summing up the respective legislative amendments which have been successively interposed in this behalf, we might naturally have expected to find the condition of man very much ameliorated by this time, through the far-rebounding benefits of civilization! Whether this is, or is not the fact, advocates  
for

for the more refined sciences will please to determine, while I content myself with a more humble sphere, in contriving ways and means to reduce such accumulated evils as a late respectable author has exhibited, by rough though substantial mechanical powers; for these would seem best calculated to bring the worthless part of Society to a sense of its duties to the aggregate whole, and, to eradicate the inconveniencies now inquired into with their many-coloured variety of concomitant mischiefs.

The author to whom I here allude, Mr. Colquhoun, in his inestimable treatise concerning the police of the metropolis of England, (1796-1797), while enumerating the various crimes and misdemeanors with which London is infested, estimates 170,000,000 pounds worth of property to be subject to daily depredations; and, after an herculean labour in collecting facts for which his judgment and assiduity seem to have been peculiarly adapted, he enumerates the detail of this cohort of very formidable depredators in the following estimated schedule.

*Estimate*

\* *Estimate of Persons who are supposed to support themselves in and near the Metropolis, by Pursuits either criminal, illegal, or immoral.*

Professed thieves, burglars, highway robbers, pickpockets, and river pirates, who are completely corrupted; many of whom have finished their education in the hulks, and some at Botany Bay

N. B. There will be a considerable increase of this class on the return of peace, now estimated at about

2,000

Professed and known receivers of stolen goods, of whom eight or ten are opulent

60

Coiners, colourers, dealers, venders, buyers, and utterers of base money, including counterfeit, foreign, and East-India coin

3,000

\* Treatise on the Police, Introductory Address, p. vii.

Thieves,

Thieves, pilferers, and embezzlers, who live partly by depredation, and partly by their own occasional labour — — 8,000

River pilferers, viz. fraudulent lumpers, scuffle-hunters, mudlarks, lightermen, riggers, artificers, and labourers in the docks and arsenals 2,500

Itinerant jews, wandering from street to street, holding out temptations to pilfer and steal, and jew boys crying *bad shillings*, who purchase articles stolen by servants, stable boys, &c. &c. generally paying in base money — 2,000

Receivers of stolen goods from petty pilferers at old iron shops, store shops, rag and thrumb shops, and shops for second-hand apparel, including some fraudulent hostlers, small butchers, and pawnbrokers 4,000

A class of suspicious characters, who live partly by pilfering and passing base money; ostensibly costard-mongers, ass-drivers, dustmen, chimney-sweepers, rabbit-sellers, fish and fruit-sellers, flash coachmen, bear-baiters, dog-keepers (but in fact dog-stealers) &c. &c. 1,000



Persons in character of menial servants, journeymen, warehouse-porters, and under clerks, who are entrusted with property, and defraud their employers in a little way, under circumstances where they generally elude detection, estimated at about — —

3,500

A class of swindlers, cheats, and low gamblers, composed of idle and dissolute characters, who have abandoned every honest pursuit, and who live chiefly by fraudulent transactions in the lottery; as morocco men, ruffians, bludgeon men clerks and assistants during the season, who at other times assume the trade of duffers, hawkers and pedlars, horse-dealers, gamblers with E O tables at fairs, utterers of base money, horse-stealers, &c. &c. — — —

7,440

Various other classes of cheats, not included in the above, (but described in pages 148 to 158, vide pages 148, 421, Tr. Pol.)

1,000

Fraudulent and dissolute publicans who are connected with criminal

minal

minal people, and who, to accommodate their companions in iniquity, allow their houses to be rendezvous for thieves, swindlers, and dealers in base money —

1,000

A class of inferior officers belonging to the customs and excise, including what are called supernumeraries and glutmen ; many of whom connive at pillage, as well as frauds committed on the revenue, and share in the plunder to a very considerable extent: principally from their inability to support themselves on the pittance allowed them in the name of salary: estimated at — — —

1,000

A numerous class of persons who keep chandler shops for sale of provision, tea, and other necessaries to the poor: the total number is estimated at ten thousand in the metropolis; a certain proportion of whom, as well as small butchers and others, are known to cheat their customers, especially those to whom they give a little credit by false weights, for which (except-

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ing in the parish of Mary-le-bone)  
there is no proper check —

3,500

Servants, male and female, porters, hostlers, stable boys, and post-boys, &c. out of place, principally from ill behaviour and loss of character, whose means of living must excite suspicion at all times, about — — —

10,000

Persons called black legs, and others profelyted to the passion of gaming, or pursuing it as a trade, who are in the constant habit of frequenting houses opened for the express purpose of play, of which there are at least forty in Westminster, where pharo banks are kept; or where hazard, rouge et noir, &c. are introduced. Of these, five are kept in the houses of ladies of fashion, who are said to receive 50l. for each rout, besides one eighth of the profits; seven are subscription houses; five have customers particularly attached to them; and thirteen admit foreigners and every idle and dissolute characters, who

are

are either introduced or known to belong to the fraternity of gamblers; where a supper and wines are always provided by the proprietors of the house for the entertainment of their customers —

2,000

Spendthrifts, rakes, giddy young men, inexperienced, and in the pursuit of criminal pleasures, profligate, loose, dissolute characters, vitiated themselves, and in the daily practice of seducing others to intemperance, lewdness, debauchery, gambling, and excess; estimated at — — — — —

3,000

Foreigners who live chiefly by gambling — — —

500

Bawds who keep houses of ill fame, brothels, lodging houses for prostitutes, &c. — — —

2,000

Unfortunate females of all descriptions, who support themselves chiefly or wholly by prostitution

50,000

Strangers out of work, who have wandered up to London in search of employment, and without recommendation, generally in consequence

sequence

sequence of some misdemeanour  
committed in the country; at all  
times above — — — 1,000

Strolling minstrels, ballad sing-  
ers, showmen, trumpeters, and  
gypsies — — — 1,500

Grubbers, gin-drinking disso-  
lute women, and destitute boys and  
girls, wandering and prowling a-  
bout in the streets and bye places  
after chips, nails, old metals,  
broken glass, paper, twine, &c.  
&c. who are constantly on the  
watch to pilfer when an opportu-  
nity offers — — — 2,000

Common beggars and vagrants  
asking alms, supposing one to every  
two streets — — — 3,000

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Total 115,000

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Whether, in reviewing this horrid cata-  
logue of offences and misdemeanours, we  
should attribute their increase to antient fe-  
verities not yet expunged from the law,  
which men are loth to execute on their fel-  
low creatures, (though indeed we now find

many species of crimes that were unknown to former ages, and appear, in a great degree, to owe their accumulation to the rapid progress of opulence and the arts) it is not for my present purpose or convenience to inquire into. It would, in any event, seem rational to conclude, in relation to villainy, that that is the best mode of punishment that can be adapted to the nature of social compact, which contributes to remedy its defects, and to attain its wisest ends at the least possible expence, with the least (but effective) degree of cruelty, in a way to compel some degree of restitution from him who has injured the community by malfeasance; and so that the aggressing individual may rather be restored to some useful function in social intercourse when he is corrected, than to be rendered an outcast under a stigmatized and irrevocable doom; or be cut off, perhaps, in the prime of life, under that social right of inanimating which the law assumes; but which I confess myself unwilling to assent to, on the mere precedent of earlier days, if it were possible to discover a more lenient substitute.

I shall therefore barely suggest a work-house amendment to the consideration of those

those in power, by means of an inclosed wheel of about thirty feet diameter, for calculation sake, leaving the actual construction, in point of size and application, to the opinions of those who may happen to be more nearly concerned; for such a kind of walking wheel requires merely the leverage of corporeal gravity put in a state of motion to employ it; and therefore places all men upon a footing of fair equality in gaining a subsistence proportioned to their bulk and appetite; being perfectly independent of tuition, mystery, art, trade, or any particular profession or habit.

With respect to the mode of erecting one of these wheels, I would recommend that it be inclosed in a room so nearly approaching to its own width, that, when the doors of the wheel were open, a complete passage should be formed through it from one room to the other, on each side of the wheel room. By this means, no other road being left open, the labourers should be made to pass through a proportionate work of the wheel in going to their meals and to their bed rooms. Their diet should be wholesome, and plentifully laid in; and always served on a plain decent

table in the room opposite to that from whence they were to depart. Compulsive measures, other than the cravings of natural appetite, would be thus spared, or greatly diminished at least. The doors of communication through the wheel should be shut with spring bolts and pullies for the management of them, so that the superintendants or directors might manage them without risque.

In a similar way, I think, the more honourable contrivance of open wheels might be constructed in various places, in order to aid poor industrious persons out of employment with a certain means of subsistence. In these, insolvent debtors, prisoners of war, and other children of distress, might obtain a little help towards a comfortable subsistence, as some little alleviation of their respective miseries.

For example, then, if we calculate the application of animal gravity, in this way, to mechanic powers for pumping water by a common forcing pump, to supply a reservoir elevated ninety feet above the ordinary surface, for feeding the ducts or water pipes of a town supplying canals, &c. we may say as follows : let the dimensions of the great wheel



wheel proposed be called thirty feet diameter. We will make choice of a pump of four inches bore, having its piston worked by a crank of nine inches sweep, admitting a stroke of eighteen inches to every movement of the piston, which is once up and down for every revolution of the crank axis.

Designing to calculate in round numbers, always throwing away fractions against our allowance of power, that we may be still more certain than otherwise against casual resistance, we are to consider that a column of water equal to eighteen inches stroke and four inches diameter, contains two hundred and twenty-six cubic inches, and eighteen fractional parts.

A column of water of this size, raised to the height of ninety feet above the surface, contains 12063 cubic inches, and weighs 7865 ounces avoirdupoise weight, or 491 lb.  $9\frac{1}{10}$  oz.

If we were to suppose each man walking in the wheel to average 150 lb. avoirdupoise, and allow him the full advantage of fifteen feet leverage, (that being half the diameter of the proposed wheel, and so far from the centre of gravity), he would produce a power at the end of the horizontal lever of 1680 lb.

after deducting an allowance of  $\frac{1}{5}$  for resistance. But as by this mode of applying levers, &c. to rotary motion, a man walking in such a wheel cannot be supposed to make good his weight above the medium angle of forty-five degrees, we must be contented to allow him the leverage of a horizontal beam as far as the intersection of a perpendicular line drawn from the point marked by the given angle, on the circle, would intersect on the horizontal beam, which is near and about eleven feet leverage, producing a nett power of 1320lb.

I will now allow each man employed to work two of these pumps of four inches bore. At this rate the resistance in the two columns of water, each 90 feet high, will be 938lb. with some little friction on the works besides ; and the power to be applied or opposed to this resistance will be 1320lb. which leaves 327lb. spare power to overcome the resistance with, and may, I presume, be considered very light labour.

Now the pistons being moved up and down in the pump, by means of the crank, as it is turned round by the trundle or spur-wheel, raises and depresses the two pump-rods, and there are two successive strokes of  
eighteen

eighteen inches each made by these two pistons for each revolution of the crank, spur, or trundle-wheel. And if the wheel which works in the spur or trundle has three times as many coggs as the spur or trundle has spurs, staves, or rounds, the spur or trundle and crank will make three revolutions for each time which the great wheel moves round; and as each crank, respectively employed, will perform its stroke, there will be six strokes discharging each a column of water eighteen inches high, and four inches diameter; containing each 226 cubic inches for each and every revolution which is performed by the great walking wheel.

Every possible care should be taken to avoid friction, by constructing the machinery so as to move the piston-rods perpendicularly. Various methods have long been tried for improving this purpose; such, for instance, as vibrating-levers, jointed crank-rods, friction-rollers of several kinds, &c. But I think none approach so near rectilinear perfection as the new method used by Mr. Foulds, at the London Bridge water works, and that by Mr. Cartwright, applied in the patented steam engine\*.

\* See Philosophical Magazine for July 1798, p. 1.

The circumference of the great walking wheel is 90 feet, or 30 yards; and the yards in a mile are 1760: which sum, divided by 30, gives  $58\frac{2}{3}$  turns in a mile.

If then we regulate the velocity of the great wheel to only two miles an hour, (which cannot, I think, be considered as very hard walking, after laziness shall have acquired the habit through inducement or coercion), there will be  $117\frac{1}{3}$  turns of the great wheel in an hour which wants but  $2\frac{2}{3}$  turns of 120, and is near enough to be considered accurate at two turns in a minute, or one revolution of the great wheel for every half minute of time.

Hence we find that six strokes are performed in each half minute of time by a wheel constructed for one person; making 720 strokes per hour. This, when fractions are thrown away against casual wastage, being multiplied by the round number 226, which are the quantity of cubic inches forced into the main-pipe and discharged by each stroke of the piston, produces 162,720 cubic inches per hour; which sum being divided by 231, (which are the cubic inches contained in a gallon, wine measure), raises  $704\frac{1}{2}$  gallons per hour. This sum, divided again

again by 63, gives above 11 hogsheads of water per hour for each man's weight, besides 11 gallons and some fractions over; which, though nothing in comparison with Messrs. Dixie and Maplestone's machine, is sufficient for our purpose in the present computation.

If thus we only appropriate 9 hours in the day to labour, (which is but a walk of 18 miles per day: probably far less than that to which vagrant habits are accustomed), it supplies (with the aid of a few fractions), 100 hogsheads per man; and this product multiplied by 6, which is the number of persons which, for farther estimates sake, I suppose a wheel to contain at a medium rate, it would give 600 hogsheads per day; which may reasonably enough be considered as a sufficient supply for an equal number of moderate sized families, obtained by the labour of six otherwise useless (perhaps criminal) beings, who have been heretofore wont to prey upon the industrious part of the community.

But if we either suppose the persons who occupy such a wheel to be men so far above the middle size as to weigh 200 lb. which is, I suppose, about the average weight of  
your

your first rate beef-eaters ; or, if you make up an equivalent to such a weight by the addition of supernumerary small men, your power will then be 1788 lb. leverage per man, equal to the full leverage of the semi-diameter in the former case, and may be supposed to work one third more pumps with ease ; which will be at the rate of 900 hogsheads per day, to a reservoir elevated 90 feet above the surface of your lower level.

Estimating all conditions of persons, then it certainly will not be deemed a severity if we say, that when any man having the use of his legs can supply 100, and some men 150 houses per day with water, through the mere application of their respective weights as a mechanical power, when applied to machinery ; and this means of getting bread is once provided for them, (making a proper distinction between those who work voluntarily, and those who are under the \* constraint of the law), there can be no need to encourage

\* It will be observed, that when six men are thus inclosed in a wheel, there will be no occasion for corporal punishments ; for the equilibrium being destroyed by the movement of one man's foot inside, or by the overseer's hand outside, the obstinate will have their choice

encourage begging in the streets by a mistaken charity, which has, I apprehend, a more frequent tendency to incommode the heart of indigent sensibility than to succour real distress.

We have seen in Mr. Colquhoun's estimate of indolence and villainy, that the persons in and about London alone who are supposed to support themselves by pursuits either criminal, illegal, or immoral, amount to no less a number than one hundred and fifteen thousand!!!

Is it not then worthy of consideration, whether the great and opulent City of London may not legally and constitutionally find those who have so long wantoned with her inadvertency some constant employment of this nature, whereby the condition of the community may be bettered; thieves and vagabonds may be compelled to make some degree of recompence for their depredations on society; and sloth may be awakened to the habit of providing food and raiment

choice to move forward or fall upon their noses; and the cravings of the stomach will be an inducement to "keep moving," when a breakfast or dinner is a thing certain at the end of a given distance.

through

through a more equitable medium than that of taxing the industry of others.

The system of national irrigation which I propose, or, in other words, the science of inland navigation, watering, and drainage, affords an abundant field for such improvement; nor do I suppose there is a city in the universe, of comparative commerce and locomotion, where a defective attention to these most productive of all resources and most interesting of all facilities is so truly conspicuous to the eyes of those who are accustomed to think on these important subjects, and who calculate the means of accumulating public wealth, and of alleviating the miserable condition of animal labour.

If we estimate upon the large scale for supplying the water of a canal elevated 90 feet above the ordinary sources of the streams, thus enabling ourselves to extend small branch canals into every part of the country, in a way to prove them assistants rather than opposers of the canals which are already constructed, we shall find that the moderate labour of these 115,000 middle sized persons (if it could either be compelled or induced), would feed no less than 341 miles of small canals per day; or the greater quantity



tity of 511 miles if large men were employed: for, if we suppose three feet deep throughout, and a proportionate width to be sufficient for this kind of conveyance, calculated to extend into and fertilize the remotest corners of the island, there will be about three cubic yards of water required for each lineal yard of canal; which is five thousand two hundred and eighty yards to each mile. And if 115,000 idlers, of the smaller weight, are supposed to work two pumps to each man they will supply 1,804,882 cubic yards, or 341 miles, in nine hours. But if the greater sized men are employed in the same wheel, they will be able to work three pumps to each man; and consequently add fifty per cent. which is 511 miles of small canal water per day: a supply, which after once being full, would probably reinstate the absorption and exhalation of the largest canal in the kingdom, to the whole extent of that distance.

Much more than this might be performed with the rotary pumps of Medhurst, Dixie, and Maplestone, &c. in their present improved state, of which I may in future have occasion to say more; and there are many other methods far preferable to my example.

The

The specimens I have given in the case of water to be raised by the common pump, may sufficiently demonstrate the capacity of this spare power of the nation for many other works in various parts of the kingdom. But it rests with the wisdom of the Legislature to draw such inferences from this sketch, as they may think interesting to their constituents.

*A Plan for raising the Supply of Water, which is delivered from the Mains to the several Houses in Bedford Square for their Use in household and culinary Purposes, up to the Roofs of the said Houses; for retaining the said Water in Cisterns, formed in the respective Roofs, so as to be ready at Hand in case of Fire; and for delivering fifty Gallons thereof per Day per House, in a pure transparent State, obtained by the Use of a filtrating Medium, resembling that by which Nature Acts in the clearest Emission of her Springs.*

It is presumed that it will be needless to introduce this subject by an elaborate notice  
of

of the great advantages which arise from an easy command of water for culinary and household occasions; nor will it be necessary, in this place, to estimate the cheapest means. It will be sufficient if it is demonstrated by an approximate estimate, grounded on the actual prices which may be now engaged in contract, that it is a matter of comparatively cheap purchase to attain a command of water ready to extinguish fire, to wash and scour the house without the labour of carriage up stairs, to promote an universal cleanliness, and to secure health and comfort in a greater degree than can be expected from the ordinary use of water charged with impurities and animalcula, and producing the dire effects of gravel and stone on the human constitution.

Bedford Square is understood to contain fifty-two houses, whose fronts occupy an average of thirty feet each, depths an average of fifty feet each, and heights about seventy-five feet.

There are five streets that enter this square, viz.

1. Gower-street.
2. A new street leading to the Duke of Bedford's grounds.

3. Charlotte-street.

4. Caroline-street.

5. Bedford-street.

If we allow these streets to occupy an average of 70 feet each, they will extend in all 350 feet on the side lines of the square; and if we add to this sum 52 houses of 30 feet each, reaching 1560 feet more along the side lines of the square, it will make the whole circumference of the square amount to 1910 feet, or  $477\frac{1}{2}$  feet diameter, or per side.

Now having stated these dimensions, it follows to premise that two methods are presented, whereby with the help of machinery, to be moved by wind, by steam, or by animal power, it is possible to distribute water from an ornamental building erected in the centre of the square, into the tops or roofs of every house at a very moderate expence; more especially when the combination of power and system are applied to the operation.

These methods are:

1. By means of an elevated tower, and chain, or forcing pumps.

2. By means of a receiver and distributor, assisted by an air vessel.

The

The first of these might be constructed in the form of a naval column similar to the monument near London Bridge, a tower, an obelisk, or a pagoda, whose height must be at least equal to that of the houses in the square; and the building required for the moving powers might either form a part of the pile or be sunk below the level line of the grass plat, so as to impede no obstacle in the prospect.

The second method (being independent of height), might be confined within the space and form of a proportionate sized temple of pleasure; and it would be easy to mold the air-vessel of the distributor in the shape of a handsome and useful statue, far better than a statue merely ornamental. In this case the horses required to fill the main pipes, would work wholly out of sight in a building beneath the level of the surface, and encircled by an iron rail, adding beauty to the temple within it, which might be accommodated with seats.

I will endeavour to make an approximate computation of the expence according to each of the several methods; but previously it is to be observed, that by the first proposed method, the easy labour of two horses

and a boy for one quarter of an hour each and every morning will be found fully competent to supply each house with one hundred gallons of water, elevated into its summit reservoir; from whence the distribution is both simple and at option, according to fancy, and the distributive arrangement of the pipes which communicate to the several apartments below the reservoirs.

Agreeable to the method which embraces the simple fountain principle, the water must be first elevated into the reservoir of the tower or pagoda, and from thence, by means of communicating pipes, it may be made to find its own level on the top of any and every house in the square; and it may be communicated along the roofs of the houses to the summit cisterns of each respectively, either in an open channel, or in a close leaden pipe with proper air-tubes, &c. In this point, indeed, the cisterns may be so constructed as to be capable of discharging their whole contents of water suddenly into the flames of any house which might happen to take fire.

There can be no invariable rule adopted for calculating the cost of the pipes below; because this must depend on the pleasure of  
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the party, in regard to the distributive arrangements which are preferred in the economy of the several families. And the lessening of expence will partly depend also on the spirit of unanimity and accommodation which prevails throughout the neighbourhood; for if any one or more of the proprietors choose to decline their quota of the expence in the general work, it can be no reason for any inhospitable objections to permitting the pipe to pass over the roof of such house to the accommodation of the next neighbour.

The expence of the central building, in this case, is entirely a contingent matter, and depends wholly on the will of the parties concerned, and the degree of ornament they are inclined to bestow on the square.

The works which come under the more particular notice of a civil engineer are matters of regular calculation, which depend on the nature of the premises, the degree of elevation, and the quantity of water to be raised in a given time. If we allow each family to consume one hundred gallons of water per day, on an average, the quantity demanded will be 5,200 gallons per day; the elevation 75 feet; and the length of

main pipe will be equal to five semi-diameters of the square, or about 350 yards, if we deduct the width of the areas which serve as front yards to the houses. One-fifth of this pipe being designed to let the water into the lower level, basin, or reservoir in the centre of the square, from the main pipes of the public water-works, should be equal in diameter to those pipes which I suppose to be four inches.

If we allow the column of water, which will be thus contained in the ascending pipe, to have an elevation of 80 feet, (for we should add a few feet for safety's sake) its weight will be about 436lb. avoirdupoise; which, together with the friction of the water acting on the pipe and the moving machinery, is the resistance to be overcome by the two horses, whose strength is to be applied to the beam or lever.

On Dixie and Maplestone's machine, the resistance against the rising water will be little more than that of the common atmosphere pressing against the buckets; for these, being fixed on an endless strap of chain or ropes, which passes in constant rotatory motion, will always balance each other.

If



If we allow the lever, to which the horses are fixed, to make good a diameter of 26 feet 8 inches, from centre to centre of the horse path, the circumference of the leverage will be 80 feet; which is exactly the pitch of the ascending main or elevation which we have adopted: and, if the buckets moved only at the slower rate at which the horses walk (which buckets I will suppose to be of equal contents to the four-inch main pipe before stated) there would be 436lb. avoirdupoise weight of water or thereabouts, which, at 8lb. per gallon, is  $54\frac{1}{2}$  gallons, discharged into the upper cistern for each time which the horses walk round the circle; making a discharge of 3564 gallons of water for one mile walking of the horses: this, at the rate of two miles per morning, would do more than supply each house with 100 gallons, and allow amply for wastage.

But as this would be a method of raising water by a very tedious process, compared with what is practicable, let us suppose the drum, pin, or sprocket wheel, round which the endless strap revolves, to be 2 feet 8 inches diameter, and it will require 10 revolutions of this wheel to one revolution of

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the endless strap which is loaded with buckets. And, if the cog wheel, which is fixed on the perpendicular shaft into which the lever or beam is framed, has four times the number of cogs which the drum or sprocket wheel has spurs or rounds, the same two horses and boy will be fully competent to supplying all the houses in Bedford Square with 100 gallons per day each by light work for one quarter of an hour each day; which labour might be performed, in routine, by the carriage horses, as a morning's exercise; and would reduce the expence of boy and horses to a total saving of this item.

The cost in this way would be approximate to the following

*Estimate :*

<i>Elm pipes.</i>	£.	s.	d.
350 yards of elm main pipe, 4 inches diameter, at 2s. 6d.	43	15	0
Laying down ditto 350, at 6d. per yard                   —   —	8	15	0
Joints, &c, at 1 foot per joint, 10 yards, at 2s. 6d.           —	1	5	0
Cartage, 350 yards, at 2d.	2	18	4
	<hr/>		
Carried forward	£.56	13	4
	<i>Leaden</i>		

Brought forward £.56 13 4

*Lead pipes.*

320 feet 2-inch ascending pipe, at 7s. per yard — —	37 16 8
1000 feet 1-inch distributing ditto, at 3s. per yard —	50 0 0
5500 feet half-inch descend- ing ditto, at 2s. per yard	183 6 8
Soldering joints, say 10 per house, 520, at 2s. —	52 0 0
Balls and cocks, say each house 5l. — — —	260 0 0
52 summit cisterns, each 6 feet every side, being 180 square feet each, in all 9360 feet, at 7lb. per foot, is 585 cwt. at 1l. 10s. per cwt. inclusive — —	877 10 0
1 Reservoir, 180 square feet, at 7lb. per foot, 11 cwt. 1 qr. at 30s. — —	16 17 6
320 feet 2-inch descending pipe, at 7s. per yard —	37 16 8
Carried forward	£.1572 0 10

Brought forward £.1572 0 10

*Millwright's work.*

Horse mill for 2 horses complete, 30 feet in diameter,  
at 4l. per foot per custom 120 0 0

*Dixie and Mapleton's machine.*

Buckets and chain complete,  
80 feet perpend. at 10s. 40 0 0  
Extra work and fixing - 10 0 0  

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1742 0 10

Allow for wooden work,  
tower, &c. - - 257 19 2  

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£.2000 0 0

Drawings, labour, and contingencies, 20 per cent. 400 0 0

Four filtering machines, each  
25l. - - - 100 0 0  

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£.2500 0 0

Engineer and superintendants,  
5 per cent. - - 250 0 0  

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Total £.2750 0 0  

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It will be here observed, that I have allowed a large estimate, and have perhaps computed a total expence greatly beyond that which would be sufficient; and for which a regular artist or practical engineer would engage to perform the work. I am aware of this circumstance, and have only to reply to it, that it seems to be often found that engineers engage for a sum, in theory, which is found very inadequate in practice; and it seems therefore better to allow roundly at first, and let the proprietor, if he is disappointed at all, be at least very agreeably disappointed.

In addition to the advantages which are promised, by this system, to household and culinary accommodation, there are many instances in which such a command of water as is here contemplated may be applied to our gratification in luxurious indulgencies: baths may be thus easily and cheaply constructed in the closets of our bedchambers, and health, strength, and cleanliness be thereby greatly promoted. Fish ponds may be thus contrived for the accommodation of private families, while the constant dripping of water may be made to cool and purify the air by means of evaporation, and a gentle breeze

breeze may be created in the mid-day heat by the action of a dinner fan, to which the water may give a mechanical motion that can be governed at will.

The grass plat in the square can be easily irrigated from the same resource; and, by passing a pipe round the top rail of the iron inclosure (at an additional expence) the bordering shrubbery can be regularly watered with little trouble; while the Spanish method of applying the perforated tube may be also adopted to lay the dust of the surrounding pavement. In short, there can be no doubt that many inestimable benefits may be derived from such a system: the difficulty, perhaps, is to find a popular mode of adopting measures of public benefit, which shall obviate the opposition of party interests, and the inertness of an enterprize which is left to the office of every body and nobody. If somebody would but step forward and be active, there seems to be no great doubt that the field itself may be rendered interesting to all; and that when once the result is demonstrated by the experience of the scite which I have chosen, for sake of a central example, this system of household economy, which Bedford Square shall

have then adopted, will emanate from thence into all the squares and streets of the metropolis, and render its influence a common blessing, by diffusing its general spirit throughout the several water-works of this populous city.

*Of watering and washing Roads.*

The following accounts of watering and washing roads are published lately in the Second Volume of Communications to the Board of Agriculture, by Mr. Wright of Chelsea, and Mr. Ellis. Mr. Wright says, "The roads that are watered in the neighbourhood of London by trustees\*, do not extend more than three miles, excepting the Brentford trust, which extends to Smallbury Green, near Hounslow.

"The watering roads is a complicated business, some being done by an additional toll from Lady-day till Michaelmas; others by an assessment on the inhabitants. No turnpike trust waters except it is specially expressed in the act of Parliament. The trustees of Kensington and Brentford have their roads done by hire; they have pumps fixed, which is attended with considerable

\* Many roads in the vicinage of London are watered at the expence of the inhabitants.

expence, and water carts of their own. The horses and men work by the day; and at the nearest calculation I can make, it costs 6s. 6d. per mile, every day they water, for the men and horses. The trustees of Islington keep teams of their own, which are constantly employed in leading gravel or watering the roads; and they find this mode cheaper and more convenient. Those roads that are watered by an assessment on the inhabitants are mostly done by contract. I am of opinion, that the mode of watering roads might be improved; the method now followed must in some degree injure them. The carts are drawn by one horse, which has not strength sufficient to pull so weighty a machine, laden with water, but is obliged to rest two or three times before the cart is empty; which causes torrents of water to rest on those parts of the roads, and occasions the holes and chasms that may be seen in all roads that are watered. The water carts, in my opinion, should be drawn by two horses to go a regular pace, that the roads might have an equal quantity of water; the trough or cullender at the tail of the cart is too far from the ground, and the consequence is, the water comes with too much force on the roads,



roads, which is in part the cause of those holes before mentioned. I am of opinion that a cullender might be contrived at the bottom of the cart, and nearer the ground, which would water the roads more regularly, and might be stopped entirely when necessary. I differ in opinion with many respecting watering roads, and think it advantageous, provided the roads be kept clean. When roads are moistened by a shower of rain, or a water cart, the perpetual pressure of the broad-wheeled waggon must bind and firm them; and the narrow-wheeled carriages at that season of the year do not remain on the ground a sufficient time to injure them. If the roads were well cleaned in the spring, and the dirt and dust carted off, a small quantity of water would make them pleasant, without injuring them; but according to the present practice, the dust or mud is raked in heaps on the sides of the roads; there it lies to be consumed and blown about, which annoys both travellers and those who live in the neighbourhood.

The watering of roads is so incidental an undertaking, that no judgment can be formed of the expence, but by the mile. If the repairing of roads were farmed, the water-  
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ing. would require but a small expence; compared to what it costs trustees. A contractor would have the benefit of all the accidental showers which happen at this season, and no time would be lost, as his men and teams would be ready for any other kind of employ, when not wanted on the roads. Trustees mostly pay for the whole day, if the teams only work a few hours. I can only add, that the principal cause of so much dirt and dust is occasioned, not by watering, but by laying on too large a quantity of gravel at an improper season of the year, namely, the summer, which does not bind, and is soon ground down to dust.

“ It might not be improper to have an experiment tried in Hyde Park, where there is abundance of water to be had, and where laying the dust would contribute so much to the health of the individuals of the metropolis. Let proper carts be constructed, with a cullender at the bottom of the cart, so that the water could not come out with such force, and it might be stopped at once, when they turn, or when the watering is not necessary. Let there be two horses instead of one, as it is too heavy a load for one horse when the cart is at all full; and let them  
water

water twice a day, at four in the morning, and at eleven, when the weather requires it; and it will soon be found, that a small quantity will not injure them; on the contrary, will bind the gravel, if it has been laid on in autumn."

Mr. Ellis has added the following remarks: "Roads upon which traffic is considerable, and the materials for mending not of the hardest quality, are apt to be extremely dusty in summer, and loaded with mud in winter. The usual method of cleaning them has been by scraping; but to this mode there is a material objection, that much gravel is carted away, as it is not easy to separate the stones which are ground down from those which are only broken. The expence of thus cleaning is also considerable. These evils occasion another, that of washing away the mud; this has been found cheaper, more effectual, and takes off only the particles ground too small to be useful. But it can be applied only in certain situations: there must be a declivity to prevent the water stagnating; it should run freely, but not with too great rapidity. Where brooks and streams cannot be turned in, which is often the case, reservoirs by the side of

of the road answer the purpose, if prepared with attention \*."

I beg leave to add to these remarks, that if the plan of national irrigation which I have herein suggested should be adopted, I can see no reason why the department for watering turnpike roads should not form a branch of the public system; nor do I apprehend that the expence of irrigating the roads by the means of perforated pipes would ultimately result in other than a saving of public economy.

\* The subjoined note is added to this paper by the Board of Agriculture:

"These hints are presented, that the Board may shew their attention has been given to every circumstance concerning the roads of the kingdom, relative to which any communications have been made to them. It would be extremely desirable, to have more complete information on the subject of watering and washing roads, from some of their intelligent correspondents, who have paid particular attention to those subjects.

*Circular Letter from the Board of Agriculture on the Subject of Irrigation; together with Remarks thereon, extracted from a Letter written to the Board on that Subject by an intelligent Engineer.*

Howsoever extraordinary it may appear, that a man seeking knowledge on the subject of irrigation, and leaving no stone unturned which might promise to afford it, (as I trust the numerous authorities cited will testify) should have omitted till the last that which many would suppose policy alone would have dictated for the foundation of his work; yet it is certainly not less extraordinary than true, that notwithstanding I have had repeated interviews with Sir John Sinclair himself, and several others of the most respectable investigators on this topic, and to whose liberal references and communications I am very greatly indebted, yet I have never been able to stumble on the following papers till my book was completed

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up to the page where I now insert them. This will appear possibly still more strange, and may perhaps be ascribed to the modest taciturnity of that indefatigable friend to agriculture, when it is known that he had paid a very early attention to the subject, and that he did not omit to notice it in the third article of the summary conclusion of his papers concerning the origin of the Board of Agriculture, in the following words\* :

“ Another separate head of inquiry, and source of incredible wealth, is, the riches to be derived from the streams, rivers, canals, and inland navigations, coasts, and fisheries of the kingdom. That many additional millions per annum might be obtained by a proper attention to those unbounded sources of national riches, can hardly be questioned. By extending inland navigation, by improving the harbours on our coasts, and by carrying our fisheries to the height of which they are capable, it is impossible to say what additional treasures might not be accumulated. That, however, must

\* Communications to the Board of Agriculture, Vol. I. p. lxxviii.

entirely

entirely depend on our making the necessary inquiries, and following up a regular system of improvement."

Thinking it necessary to call the attention of the community to the advantages of applying waste water from the canals to the purposes of irrigation, he has also subjoined the following circular letter, with remarks made in answer to it by an experienced engineer.

*Circular Letter to the Canal Companies.*

" I am requested by the Board of Agriculture to submit to your consideration a subject of considerable national importance, *that of applying navigable canals to the purpose of irrigating or watering land.* We have every reason to believe, that the canals already formed, or now forming, might be made applicable to this very material use, without any injury to their common destination; for though it might not be proper in many cases to spare water in summer,

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mer, yet in winter and spring, when most abundant, and least essential to navigation, its utility, if thrown on the adjacent lands, would be indisputable; and by this means a considerable revenue might accrue to the owners of canals, by granting certain quantities of water, weekly or monthly, to the proprietors of the adjacent ground, and infinitely to the advantage of the public.

“Should this idea meet with your approbation, the Board would apply for a general act of Parliament, to permit the proprietors of canals to make this use of their waste water, and for any other general regulations respecting canals which may be thought necessary, and which you might have the goodness to suggest. The act might pass so early, that it might be in your power, in the course of the ensuing winter, to try experiments on the practicability of the measure. Engineers, skilled both in navigation and irrigation, would soon ascertain what quantity of water could be spared from each canal, at the different seasons of the year, and the extent of land over which it might be conveyed. It may not be improper to inform you, that this use of navigable canals has  
long



long been common, and carried to a considerable extent in the Milanese, where the rents paid for water thus taken have in some cases equalled the expence of forming the navigation; that this plan has rendered that part of Italy among the most fertile and opulent in Europe, and contributed more to the improvement of the country than any other idea that has been adopted. It is from the water meadows thus obtained that the celebrated Parmesan cheese is in many instances produced.

“The anxiety felt by the Board of Agriculture for extending the benefits resulting from your useful undertakings to new objects, which might prove equally beneficial to yourselves and to the public, has occasioned this trouble on the part of,

“GENTLEMEN, &c.”

*Extract of a Letter from an intelligent  
Engineer on the foregoing Subject.*

“ I have received your circular letter respecting the plan of watering of land by the means of navigable canals ; on which there ought only to be one opinion as to its being a point of the greatest importance, which could have come under the consideration or patronage of the Board of Agriculture ; and if any obstacles should occur, they must arise from prejudices which time will wear off ; for that such a rational application of the waste water of canals will at one period or another take place, seems not to admit of a doubt.

“ In Europe, the improvements of the Milanese are a striking instance of the fertility which may be created by such an application of the waste water of canals ; and if any thing else was wanting to add to this conviction, the economy of the waters of the Nile may be produced as another instance, and perhaps even a more striking one than the Milanese ; as in this  
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last case, an unrivalled fertility was spread over the sandy wastes of Egypt and the Thebais, and even over the scorching plains of Lybia.

“ The lake Mœris, formed as a reservoir in the bosom of barren mountains, is a feature which cannot be mistaken; and it ought to prove a useful lesson for the management of rivers in general, most of which, in some place or other, may be treated in the same way: the excess of floods may be drawn off, and in dry seasons water may be issued for the use of navigations of the same rivers, for the working of mills, for the purposes of watering land, and for supplying navigable canals.

“ The very lakes which now exist in Great Britain may in general, and at a very moderate expence, be raised a few feet above, or drawn off a few feet below, their usual level; and this, upon extensive surfaces, would supply a quantity of water which would produce much fertility to the countries which lie below that level.

A general survey of the kingdom, directed so as to ascertain the comparative levels of its surface, would be a very necessary step  
towards

towards the general management of water ; and this survey should be made with great accuracy, and noting the leading objects and peculiar advantages and disadvantages in each district, with their relative situations as to the connecting districts ; and from these separate reports and surveys a general arrangement of the whole might take place, and many useful plans be pointed out.

“ In general, I should suspect that in this business there are evils to be guarded against, and which are likely to arise from two very opposite classes of people. In the one class may perhaps be ranged those land-owners and mill-owners, whose minds are not sufficiently enlightened as to be sensible of the general utility of the scheme, or the benefits which must eventually arise to themselves ; and they, of course, will be averse to submitting to any alterations which may interfere with the water.

“ And the other class will consist of projectors and projecting engineers, who may be in any shape engaged in the arranging or executing this plan, and who being wholly engrossed with new schemes, may be led to despise real obstacles, and give a favourable complexion to impracticable projects.

As

As the first, it is hoped, will not form a majority of the community, an act of Parliament will remove all legal obstructions as far as it respects them; and a perseverance in repeating calm demonstrations, and the sensible operation of the scheme itself, must in the end convince them, that so far from this plan proving an injury or injustice, that not only the country at large demands it, but that they will be benefited individually; indeed, there is no reason but their own obstinacy, why they should not be benefited immediately, and that in a double capacity; because, as canal stock is transferable and fluctuating, these land-owners and mill-owners may become proprietors of the canal navigations, and so receive a share of the advantages arising from this distribution of water, and they may likewise, in this way, have a voice in the direction of its operations.

“ And besides this, canal stock seems more than any other property to connect the apparent interests of the greatest number of individuals, with the improvement of the land and manufactures of the counties through which the canals pass, since it is in proportion to this prosperity that the canal proprietors can receive their pecuniary ad-

vantages from an increased tonnage: thus a number of persons residing in distant quarters of the kingdom, who probably could never have become land-owners, are in this way intimately connected with the improvement of the land, &c. This is the circumstance that I take the liberty of mentioning more at length, because I do not recollect that it has hitherto been taken notice of; and it appears to me of considerable importance. I have for instance observed, that in a certain inland canal navigation, where there are upwards of 1200 proprietors, most of them people in tolerable circumstances, and in trade, and residing in twelve counties; that all of them are looking with anxiety to the increasing produce and consumption of Cheshire, Derbyshire, Montgomeryshire, and Shropshire, although, if it had not been for this circumstance, very few of them would have known or have concerned themselves about that part of the country,

“ With regard to the being led astray by projectors, or projecting engineers, this may be in a great measure prevented by the choice in the appointment of the engineers who are to take the surveys, and the Committee under which they shall act, and the care to  
be

be taken in the comparing and arranging the several reports and surveys, and many of the Members of the Board of Agriculture will, from their own local knowledge, be enabled to check any false representation."

Before I dismiss this subject, I feel it a duty which I owe to inventive talent, and to the unpatronized engineer, of self-taught abilities, to take some notice of a hackneyed habit which many professional men have adopted in respect to the prosperity of Genius; who they affect rather to consider and treat as the enemy of the arts, than the parent of human improvement, and of all the old beaten-track knowledge which tuition and time has been able to beat into that invariable system, the ultimatum of their capacity. One would suppose, also, from the extreme care which some are wont to take in their cautions concerning the public interests (permit me to say a little out of their path in trade) that they either considered the Board of Agriculture and Parliament as a parcel of political schoolboys sent to London for their instruction; or that they were distrustful of their own strength: had forgot that projection is the science which alone can complete a mastership in their most ho-

nourable profession, and give them bread, or perhaps their good luck in being heretofore employed by men who were either too proud, too weak, or too dissipated to look into their own affairs, had induced them to view the Board of Agriculture as cattle of this description. I can only say, that on a review of the premises, (let what will have been the motive) common reason would seem to revolt at its dictatorial impudence, and its grovelling illiberality. The mighty work which established this grand national institution, (from which all the world have derived extraordinary light and benefit) has nothing selfish: yet Sir John Sinclair, whose unparalleled zeal will record him among the benefactors of man, to the latest period of time was a *Projector*.



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## ERRATA.

Page	8,	line	5,	for works, read works of
	38,		8,	for Mornavian, read Meravian
	55,		13,	for waters, read <i>water</i>
	75,		4,	for irrigation, read <i>irrigator</i>
	110,		1,	for to lamented, read to <i>be</i> lamented
	118,		10,	for recommends, read <i>advifes</i>
	129,		4,	for culvers, read <i>culverts</i>
	137,		3,	for dying, read <i>drying</i>
	155,		16,	for their, read <i>the</i>
	187,		1,	for land, read <i>sand</i>
	198,		23, 24,	for that all elevated countries which, read, that <i>the people of</i> all elevated countries <i>who</i>
	205,		3,	for as Shadwell, read as <i>the</i> Shadwell
	211,		18,	for let sat, reads <i>lets at</i>
	220,		1,	(in the note) for Farmers, read <i>Fenna's</i>
	260,		10,	for Westdale, read <i>Wafdale</i>
	262,		14,	for portage, read <i>partage</i>
	352,		4,	for Lumbefton, read <i>Lumberton</i>
	365,		4,	for nd, read <i>and</i>
	367,		27,	for characters, read <i>character</i>

THE END.

# **PRACTICAL TREATISE**

**ON DRAINING**

**BOGS AND SWAMPY GROUNDS, &c.**





A  
**PRACTICAL TREATISE**  
ON DRAINING  
**BOGS AND SWAMPY GROUNDS,**

ILLUSTRATED BY  
**FIGURES;**

WITH  
CURSORY REMARKS UPON THE ORIGINALITY OF  
MR. ELKINGTON'S MODE OF DRAINING.

TO WHICH ARE ADDED,  
*Directions for making a New Kind of Strong, Cheap, and Durable Fence, for Rich Lands; for Breeding, at little Expence, Mill-Dams, or Weirs upon Rivers, that shall be alike Firm and Durable; for effectually Guarding against Encroachments by the Sea upon the Land, and for gradually raising Drowned Fens, into Good Grass-Lands.*

AND ALSO,

DISQUISITIONS CONCERNING THE DIFFERENT BREEDS OF  
SHEEP, AND OTHER DOMESTIC ANIMALS;

BEING

The principal Additions that have been made to the Fourth Edition of  
**ESSAYS** relating to **AGRICULTURE** and **RURAL AFFAIRS**,  
published separately, for the Accommodation of the Purchasers of the  
former Editions of this Work.

BY

**JAMES ANDERSON, LL.D. F.R.SS. &c. &c.**

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MEO SUM PAUPER IN AERE.

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L O N D O N:

PRINTED FOR G. G. AND J. ROBINSON,  
PATERNOSTER-ROW.

1797.

## ADVERTISEMENT.

*The Author returns his best acknowledgements to those gentlemen who have obligingly offered to come forward with attestations of the success they have had, in following the directions given in former editions of this Work ; but hopes, they will permit him to decline their obliging offer on the present occasion. He has no anxiety on this head ; and is perfectly satisfied to leave his Treatise, as formerly, to the unbiassed judgment of an impartial Public, which he is conscious can never fail, ultimately, to decide with the most impartial justice.*

## INTRODUCTION.

THE principal part of the following Essay was first published in the year 1755, exactly as it now appears, (verbal corrections excepted) and had passed through three editions before the year 1795, when the President of the Board of Agriculture brought forward a motion in parliament, to obtain a premium of 1000*l.* to be given to one Mr. Joseph Elkington, for *discoveries* said to be made by him in the art of draining land. This naturally called the attention of the author to a subject, on which he had formerly written himself; and from the particular enquiries he made, he found reason to be satisfied, that the only particular in which Mr. Elkington's mode of draining differed from that practised in general throughout Britain, consisted in what he called, *tapping* for springs, a mode of draining which had been practised by the author more than thirty years before, and which had been particularly  
B described

described and illustrated by figures in the first edition of these Essays. On this occasion, without any intention either to frustrate Mr. Elkington of his premium, or to claim any gratuity to himself, the author thought it expedient, politely by letter, to inform Sir John Sinclair of the mistake he had inadvertently fallen into, in ascribing that practice, as *an original invention, exclusively* to Mr. Elkington, and producing a quotation from this Essay, as a decisive proof that it was not a new thing. Sir John Sinclair, without advert-  
ing to those facts, chose afterwards to state, in two separate publications, in the most decisive manner, his opinion of the undoubted right that Mr. Elkington had to claim this invention *exclusively* as his own. This drew from the author a second letter to Sir John, in which the justice of that decision is controverted, and in which the author calls upon the Board of Agriculture to publish an account of Mr. Elkington's mode of draining, that the public may be enabled to judge impartially in this case. These two letters are here subjoined for the purpose

AND SWAMPY GROUNDS. 3

pose of more clearly elucidating this subject.

---

TO SIR JOHN SINCLAIR, BART.

PRESIDENT OF THE BOARD OF  
AGRICULTURE.

LETTER FIRST.

SIR,

*Cosfield, near Edinburgh,  
30th June, 1795.*

I USE the freedom to trouble you at present, on the subject of draining, adopted by Mr. Elkington, not with a view to detract from the merits of that gentleman, nor to find fault with the remuneration you have obtained for him, but merely to set you right in regard to a matter of fact concerning me, which might easily escape your notice.

I presume, Sir, you thought it evident, from the statement made by Mr. Elkington, that the mode of draining ground, which has been so successfully practised of late, by that gentleman, was an invention peculiarly his own. That this is not the

B 2

case,

#### 4      ON DRAINING BOGS

case, admits of evidence, which, I hope, you will allow to be satisfactory. It is now twenty years since I published a book, called *Essays relating to Agriculture and Rural Affairs*. If you will take the trouble of turning to the second Essay of that work, which is *On Draining Bogs and swampy Ground*, you will there find the method of draining by means of *tapping*, which has been adopted by Mr. Elkington, fully explained, and the principles upon which it may be practised, clearly developed, by the aid of illustrative figures, discriminating plainly the cases in which that mode of practice would be improper.

I do not understand that Mr. Elkington practised this method of draining before the publication of that work (anno 1775) neither do I mean to assert that he adopted the practice from the directions there given. I readily admit that the principle is so simple, and so obvious to every considerate mind, that it would certainly be nothing extraordinary, if he, by his own reflections alone, should have discovered it, as well as I did. There is only one particular

## AND SWAMPY GROUNDS. 5

particular in his mode that I myself had not practised before that Essay was published, viz. the making the tapping by means of *a boring instrument*; but even this I have particularly described, as you will find in the following words, at page 181 (*Third Edition, Vol. I*) of the foresaid Essays. After describing the mode of tapping I had adopted, by sinking small pits, and explaining the cases in which it may be successfully practised, it is added, “ I have often imagined that the expence of digging these pits might be saved, *by boring a hole through this solid stratum of clay, with a wimble (an auger) made on purpose*; but as I have never experienced this, I cannot say whether it would answer the desired end exactly.”—Neither can I *now* say, whether Mr. Elkington grounded his practice on this hint or not; but I may safely say, if he did not, he might have done it: And as I could not have borrowed it from him, if there be any merit in the *discovery*, I have assuredly a just title to claim it.

I wish not to throw out any insinuation to the prejudice of Mr. Elkington, who,

by a proper degree of management on his part, has great merit in having turned the attention of the nation towards a mode of draining, which, if the principles upon which it is grounded, are fully understood, and properly applied, will be found to be equally cheap and efficacious; as I myself, from an experience of it for more than thirty years, can safely assert. But it is a mistake, to think it can be universally applied. There are many cases in which it can be of no use, and, therefore, it were vain to attempt it; as I have fully demonstrated in the Treatise referred to.

Whether Mr. Elkington did actually discover this mode of draining of himself, or adopted it from the very plain directions given in that Treatise, is of little consequence to the Public. In either case, he has alike the merit of having introduced it into practice in the southern parts of this Island: for the simple fact that he has been supposed to be the first inventor of it, is the clearest proof that this part of my Treatise, *by how many soever it may have been read*, has been allowed



lowed to remain, in a great measure, a dead letter, even till the present hour.

As my intention in publishing that Essay, doubtless, was to benefit the public, I owe, perhaps, thanks to Mr. Elkington, for having thus forwarded that design. It is not impossible that the time may not be far distant, when I shall be laid under a similar obligation to some other person, for bringing into practice, *as a new invention*, the mode of embanking rivers, which is described in the Essays referred to, with a similar degree of clearness; and which, when reduced into practice, will be an improvement equally cheap and efficacious with the above. An obligation of this sort was conferred upon me, some years ago, without my knowledge of it at the time, by a Mr. Brodie, I think the name is, when he brought into notice, what he called, the *Patent Bath Stove*; the principle upon which that stove is constructed, having been explained, and clearly illustrated by means of a plate in a Treatise of mine “On Smoky Chimneys,” that was first published in the year 1769; but this particular was little adverted to for

several years, till Mr. Brodie, by a *little proper management*, brought it into notice†. My ideas, freely communicated to the public, have been a source of emolument or of honour to others also—my own reward has been the satisfaction of having done what I know to be right, and the *honour* of being indirectly flattered by compliments that were publicly appropriated to others.

Wishing you success in your laudable undertakings, which, if properly supported, cannot fail to be attended with effects highly beneficial to the nation, I have the honour to be, with due respect,

Sir,

Your most humble servant,

JAMES ANDERSON.

† It is generally believed that Mr. Brodie has realized a hundred thousand pounds by this contrivance.

## AND SWAMPY GROUNDS. 9

### LETTER SECOND.

*Cotfield, near Edinburgh,  
10th January, 1796.*

SIR,

SINCE I had the honour of addressing you in public on the subject of draining land, I have learnt that a controversy has been carried on in the Newspapers to some length, upon the same subject, by various persons. Who these persons are I know not; and with the particular object that each party has in view, I am in a great measure unacquainted. I never saw one of these publications (except two, which accidentally fell into my hands in September last, when I passed through London). The present letter, therefore, must be considered as having no connection with, or reference to these publications; and if any thing shall here occur that shall tend either to corroborate or oppose any of these writings, it must be considered as merely accidental.

Since my own letter, above alluded to, was written, I have seen two publications, by the President of the Board of Agriculture, in which the draining of land has been mentioned. The first is an Address to  
the

the Board of Agriculture, dated 14th July, 1795, in which it is ~~taken~~ notice of in these words: ‘ The Board has succeeded  
‘ in its first application [i.e. to Parliament for a reward on account of *discoveries* advantageous to Agriculture] in behalf of a  
‘ very deserving individual, Mr. Joseph Elkington, *who has carried the art of draining to a perfection hitherto unknown.*’ The second is an Address to the Board of Agriculture, on the cultivation and improvement of the waste lands of *Great Britain*, by the President, printed 23d December, 1795, in these words: ‘ A considerable  
‘ proportion of the wastes of Great Britain  
‘ consists of lands of a wet and boggy nature, which it has been yet supposed was  
‘ the most difficult to improve and cultivate.  
‘ Fortunately, however, *discoveries* have been  
‘ made in the art of draining such bogs,  
‘ by Mr. Joseph Elkington, a farmer, in the  
‘ county of Warwick, as renders the improvement of swampy land a matter of  
‘ much less difficulty or expence than formerly.’ My friends think that in both these passages there is manifestly a *marked* determination to set aside my claim  
to

to any share in the discovery of that mode of draining, and a studied care to avoid my name in any way, lest it might imply some sort of derogation from the merit of Mr. Elkington; and they farther think, that after the public claim I have already made to that discovery, it would argue little less than a consciousness of the injustice of my claim, should I suffer such a public affront to pass unnoticed. As some of Sir John Sinclair's best friends with whom I have spoken upon the subject concur in the same opinion, I find myself called upon to urge a farther explanation on that head; which is one of the principal objects of the present Address.

The question at issue may be reduced to a very narrow point, which is this: The practice of Mr. Elkington is, in its principle, either the same with that which was practised by me, more than thirty years ago, and the principle of it developed and clearly illustrated by figures, in Essays relating to Agriculture and Rural affairs, which were published in the year 1775; or it is not. If it be the same, then, doubtless, Mr. Elkington can have no just title  
to

to be held out to public view, *exclusively*, as the discoverer of this practice; for I presume, he will not allege that at the time of the discovery, I had ever heard of him or of his practice. Indeed, I never did hear of either, till his name was first mentioned in some of the publications of the Board of Agriculture. On the contrary, as it is certain that my discovery was published more than twenty years ago, and that Mr. Elkington has never till this hour published his, but has been going on from imperfect beginnings, gradually improving as he went on, it is not so clear that he may not have borrowed some hints to direct his practice, either directly from my treatise, which has been pretty generally read in Lancashire, or from the conversation of some persons who had read it. From these considerations, if the principle be the same, it will be difficult for the President of the Board of Agriculture, to clear himself from the imputation of a marked partiality in the passages above quoted; especially after my having pointed out to him, in my former letter, the passages in  
my

my Essays, that directed the same method of practice so long ago, as has been already specified. If, on the other hand, the practice followed by Mr. Elkington differs in principle from that which I had so long ago explained; in that case, the President of the Board of Agriculture may be with reason accused of injustice to the public, by having delayed so long to explain the principle of that useful discovery; for, as the public have already paid for the discovery, they have a right to demand that it should be made more generally known for the benefit of the whole community, in the same manner as Mr. Forsyth's receipt for recovering decayed trees was published, on receiving his premium. I therefore, in the name of the public, demand of you, Sir, who have taken the lead in this transaction, to publish this secret, that all the world may be enabled to know it, and to avail themselves of it, if they incline, without being obliged to have recourse to Mr. Elkington himself, who in this instance, like the venders of quack medicines, carefully conceals his secret, that he may be enabled to pro-

fit by the credulity of the public: And shall the President of the Board of Agriculture, demean himself so far, as to give countenance to such transactions!!!—I will not suppose, that such can be the case. Yet appearances are against you.—Inadvertence may have led you to adopt a language that is fairly susceptible of that interpretation; and you cannot take too early an opportunity of doing it away.

It will be the easiest thing imaginable for Sir John Sinclair to clear himself from this charge, and settle the matter,—simply by publishing the principles on which Mr. Elkington's method of draining is founded. This can be attended with little trouble:—For as Sir John must fully understand the principle himself, (otherwise it would be an insult to suppose he could have adopted a language so strong and decisive as he has done)—he can find little difficulty in explaining it, as a supplement to one of those publications that are every day issuing from the press, at the expence of the Board of Agriculture,

Such



## AND SWAMPY GROUNDS. 15

Such a publication is likewise necessary on Mr. Elkington's account, if he means to free himself from the imputation of quackery; which idea, the manner in which he has been introduced to public notice, by the Board of Agriculture, has a strong tendency to countenance. This ought to be done away, if he wishes to gain that respectability of character, to which superior talents should naturally entitle him. With such men, *candour* is ever a leading characteristic feature; for, however far concealment and deception may lead to emolument in certain cases, it never can be accounted honourable. Now, if Mr. Elkington is sensible, that he understands the principles upon which his practice is grounded, so completely as to be able to explain it in such a satisfactory manner, as to set at defiance the critiques of philosophical investigators, he can have no objections to publish it. He has received a price for it; and not only honour calls for it, but *justice* requires it at his hand. If neither the President, nor any other member of the Board of Agriculture, nor Mr. Elkington himself, shall, after being

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thus

thus called upon, publish the secret that he has sold, the public will be disposed to believe that Mr. Elkington cannot do it, and that he has availed himself of the influence of some great man, to impose upon the President and the Board of Agriculture, who have thus, in their turn, been induced to lend their aid to enable him to dispose of his nostrum to the best advantage. From these considerations, it alike behoves the President, the Board of Agriculture, and Mr. Elkington himself, to lose no time in publishing his secret. Among other good effects that will result from this measure, it will totally preclude all farther altercation respecting the merit of this discovery between him and myself, or others.

Till such publication appears, it may not be improper in me to observe, that another body of men, who have had good opportunities of information, have thought proper to adopt a conduct, respecting this particular, very different from that of the President of the Board of Agriculture. The gentlemen who compose the Society of Agriculture, at Altringham, near Manchester,

chester, in the county of Lancaster, having determined to encourage the draining of land by means of tapping, judged that a respect for their character required them, in this case, to act with the strictest impartiality: And thinking it would be of use to those who were to attempt it, to know the principle on which success depended, as well as the mechanical practice of the art, the Society offered a premium to those who drained the greatest quantity of land, ' according to the practice followed by Mr. Elkington, on the principles explained by Dr. Anderson, in a book called Essays relating to Agriculture and Rural Affairs.'

The following is Mr. Elkington's own account of the way in which he was first led into the train of discovering his mode of draining by means of tapping, as it was told to me by a gentleman of great veracity, who had it from Mr. Elkington himself; and it appears to be so natural, as fully convinces me that it is strictly the truth. Mr. Elkington's father having died about the year 1763, left him in possession of a small farm of wet sour land.

He found that no good could be made of it without previous draining. He accordingly set to work to drain it in the usual way; but after having laid out as much money as his narrow funds could afford, he had the mortification to find that no benefit had resulted from his labour; which tended very much to discourage him. While he was in a state of despondency on this account, he, by accident, dug a little deeper than usual in one of his drains, and found, to his great surprise, that a copious spring of water burst forth from the hole, which continued to flow with a plentiful stream for a very long period of time. He dug deeper, in several other places, with the same effect, though the streams were less copious than the first. In consequence of these openings, he had the satisfaction to perceive, that his fields gradually became drier and drier, till they at last were perfectly freed by it from all the superfluous moisture. And not only were his own fields thus drained; but the contiguous land, for a considerable distance all round, was made drier also by the operation. This circumstance led him  
to

## AND SWAMPY GROUNDS. 19

to suspect, that in other cases, where the surface appearance of wet land was somewhat similar to his own, they might be drained by making openings resembling those above named. Success attended his operations in many cases; and he gradually went on in his practice, correcting his first errors by experience, and improving upon it till the present time.

From this account, it would seem that the discovery was, as to him, merely accidental; nor does it appear, from the above, that he had any clear idea of the manner in which the draining is thus effected, or the principles on which it depends, so as to be able to distinguish *à priori*, those cases in which that mode of draining could be of no use, from those where it must of necessity prove efficacious.

As to myself, the discovery of that mode of draining was made in the following manner: I had a field of wet land that lay very flat, but so surrounded by ditches, that no surface water could come to it from higher ground any where, and possessing at the same time such a level as to prevent any water from necessarily stagnating upon

it. The field was so wet, that in many places it was a mere hobbling bog, over which a man could scarcely pass during the driest weather in summer. This was a very unprofitable as well as disgusting object; and, in the beginning of the year 1764, I set about seriously to have it drained. On considering the circumstances of the case with attention, I soon perceived that as no *surface* water could come upon it from the higher ground; and as the rain that fell upon the field itself was suffered freely to run off, the water that drowned it must rise up from *below*. But as the weight of the atmosphere acted on this field as well as on those around, the water could not be made to ascend, as in a pump, by means of suction: it must, then, be forced to take that direction in consequence of some powerful pressure from below ground, acting so strongly as to overcome its natural gravity. This pressure, it was evident, could only be in consequence of the water flowing from higher ground, *under the surface*, through a stratum of pervious matter, being pent in near the bottom,

## AND SWAMPY GROUNDS. 21

bottom, by a stratum of clay placed above it, and thus forced to rise to a higher level, than the low ground, in this kind of subterraneous canal, so as, by the natural power of gravity, to be squeezed forcibly through small fissures in the superior stratum of clay. If so, it would necessarily follow, that should a hole be dug through the superincumbent stratum of clay, so as to reach the bed of the reservoir, the water would be allowed to issue freely through that opening, and to run off the ground by its natural level; and thus would the accumulated water, which occasioned the pressure, be gradually discharged, after which, it could no longer be forced up through the small fissures in the clay; and, of course, the wetness, which had arisen solely from that cause, must be gradually removed. On this reasoning, which seemed perfectly conclusive, and which was confirmed by observing that the subsoil of that field was every where a very stiff clay, mixed with small stones, the dry weather was no sooner set in, than I put a man to dig a pit as near to the

edge of the swaggle as he could approach, ordering him to penetrate directly downwards, making the pit no larger than was sufficient to allow him to work, and to proceed without interruption, until he should perceive that, on making his strokes, it should sound as if it were somewhat hollow below. On observing this, he was desired immediately to desist, until he called me, and received farther orders. The labourer accordingly fell to work; but he found the ground so hard, that, in the course of two days, he had only penetrated to the depth of about five feet. During that time, I frequently visited the work, to examine appearances. Nothing remarkable occurred, save that little peering springs often were discovered, through which the water issued; but the quantity of water that came from them was not such as to interrupt the work. On the morning of the third day, about breakfast time, the labourer called on me, and said, that as his stroke gave a *douf sound*, (that was his phrase) he had called me, according to my desire. I went immediately with him to the place, and having  
made



made him go down into the pit, I desired him to show me in what manner he could come out of it. He then pointed out to me, a kind of steps he had made into the clay on one side; and having lent him my hand to assist him, I found he could get out very quickly. I then ordered him to take a kind of sharp-pointed iron crow, with a cross handle and foot to it, which he had found a very useful tool in loosening the clay, and give a stroke of that with all his force upon the bottom, which he did.—On this, to his great surprize, the tool penetrated a thin crust, and then fell down, from one to two feet, as in a vacuity. Through the opening thus made, a strong jet of water rushed instantly with great impetuosity; but I, being aware of it, and at hand to assist the man in mounting, he got very quickly to the surface, and out of all danger, though not a little terrified at what had happened. The stream was at first so large, as might, I suppose, have filled a pipe of from six to twelve inches diameter; and rose, as a *jet d'eau*, to the height of six feet at least, above the surface of the ground. The labourer, who had no idea of such a phe-

nomenon, looked upon it with an overpowering astonishment, which would have furnished a fine subject for the painter. The stream continued to flow, and to rise above the surface of the ground for about a week; but gradually abated in height, till it arose not above the surface of the ground, and continued still to flow; but the quantity of water gradually diminished, till it at last settled into a perennial spring, which continues to run till the present day.

The consequence of this operation was, that during the course of the ensuing summer, the water gradually drained off from the boggy ground; the swaggle slowly acquired a firm surface, so as to admit of being ploughed at any season; and about twenty acres of ground were thereby drained, which, before that time, had been, in a great measure, useless for every agricultural purpose.

Ten years afterwards, being about to publish an Essay, containing directions for draining all the different kinds of wet grounds that occasionally prove detrimental to the farmer, I naturally specified this variety of wet ground among the others, and gave a plate  
explanatory

explanatory of the cause of that phenomenon, as I had done of the others, in order that every person who chose it, might be enabled to distinguish the case, and apply the remedy himself, if he so inclined. The Essay has been now in the hands of the public above twenty years, and will speak for itself; so that more need not be said here on that head, farther than that all these facts could be *proved*, were it thought necessary to do so.

I may add, however, at present, when I find that a disposition is manifested, on some occasions, to withhold honour from those to whom honour is due, that though I did not think it proper in a work that professedly treated of agricultural concerns only, to specify all the useful corollaries that might be drawn from the physical appearance above explained; I may now, without any impropriety, barely mention, that from the application of this principle, many phenomena may be explained in a very satisfactory manner, which have been hitherto reckoned cases of great difficulty. Some of these, (particularly the case of a well that was sunk at Tilbury Fort, on the Thames, as narrated

rated in the Phil. Tran. Vol. in which an abundant spring of *fresh* water was found, at a great depth below the surface of the sea, after two springs of *salt* water had been passed through above it) I pointed out, in a letter I did myself the honour to write, several months ago, to Leigh Philips, Esq. of Manchester, who had been kind enough to say, that the essay referred to, was what he conceived to be a *complete system of draining*. This expression induced me to show him it could not be deemed *complete*; as several cases were omitted, which I then specified to him: among others, it was stated that deep lakes, surrounded by mountains of great height on all sides, may, on some occasions, be entirely drained, by *bor-ing*, or sinking shafts downwards, sometimes to a moderate depth: That also, wet-land may, on some occasions, be more easily drained, by opening an outlet for the water *beneath* the reservoir which occasions the wet, than by bringing it up to ~~the~~ surface. And that among mountains, it may frequently be much cheaper to carry off superfluous water from mines, by penetrating downwards, than by driving a horizontal level

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level to the surface of the ground, which is in many cases attended with a ruinous expence. These corollaries are indeed so obvious, when the principle is once explained, that it must appear astonishing to any considerate mind they have not been made, and very generally applied in practical cases, long before the present period; and I here specify them, merely to direct the attention of men to an object from which much practical good may be derived, in a variety of cases, which it would be tiresome in me here to enumerate.

I have farther to add, on this head, that there is one variety of wet ground which had totally escaped my notice in that Essay, and which has not, that I know of, been treated by any writer on agriculture; though it is perhaps more universally hurtful to the farmer, than any other kind of wet land whatever. This I shall have occasion particularly to explain, in a treatise now in the press, on the improvement of waste lands,

From the facts that were stated to the committee of the Board of Agriculture, in favour of Mr. Elkington's mode of draining,

draining, as published in their *report*, dated June 5th, 1795, there seems to be reason to suspect, that Mr. Elkington himself, even at that period, was not fully aware of all the circumstances that were essential to the practice of draining ground, in the most economical manner, by means of tapping;—as the labour and expences incurred, in many of the cases there specified, seem to be much greater than that mode of draining, judiciously applied, could possibly have required. But as these cases are stated by gentlemen who did not themselves fully understand his method, they may possibly have been done with some degree of inaccuracy. When Mr. Elkington himself shall publish his own method, that doubt will be removed; and every individual will then be able to judge for himself as to this particular. If his practice be as good as it is said to be, it cannot be too soon or too generally made known. If it shall be defective in any respect, these defects cannot be too soon pointed out and rectified; which would probably not be long delayed after the publication required.

I shall

I shall be sorry, if, in consequence of the precipitate conduct of Mr. Elkington's friends, I have been obliged, for the purpose of obtaining impartial justice, to say any thing here that may tend to prove, in the smallest degree, detrimental to that gentleman. I look upon him as a very worthy member of society; and I believe him to be an honest man. I have not a doubt but his practice has already been of much national utility, and will be of still more, the wider it is diffused; even although it should not be carried on in the most perfect manner of which it will be found to be ultimately susceptible: and I can assure that gentleman, with much sincerity, that there is not a man in the land, not the President of the Board of Agriculture himself, nor his still more powerful patron, who will rejoice more in his prosperity than myself, or who would more gladly lend his aid to the extending his practice as wide, and the rendering it as perfect, as possible. It is, perhaps, unfortunate, when a plain man finds himself forced to come forward in the genteel circle,—especially where such person  
may,

may, by the ill-judging partiality of ignorant friends, be induced, from the hope of benefiting his family, to acquiesce in statements that he himself would never perhaps, have made, even though he be backed by those who have the most powerful influence: For it is not in this nation, that influence can altogether suppress the voice of reason, or ward off entirely the severity of reprimand, when the influence of supposed power provokes a scrutinising enquiry.

I have now, Sir, done with the business of Mr. Elkington, but am sorry, that, in justice to myself, I am not yet at liberty to put an end to this, I fear, ungracious epistle.

It appears to me very strange that I should have occasion, at one time, to complain of having been ill used in *two* respects, by Sir John Sinclair, as I am not, conscious of ever having merited any thing of that sort at his hand, *but much the reverse*. It unluckily happens to be so, however, at present. The trespass, too, is of such a kind as to require that notice should be taken of it in the public manner

I now



## AND SWAMPY GROUNDS. 31

I now do, in order that I may remove, in part, at least, the injury that, by his improper conduct, must have been done to my character. I shall briefly state the facts, for the justness of which statement I appeal to yourself.

Immediately on receiving a letter from the President of the Board of Agriculture, in February last, requesting that I would favour the Board with any information I could give respecting the culture and uses of Potatoes; I sat down, and in great haste, put upon paper such observations as occurred to me at the moment. These observations, without revision or corrections, were instantly forwarded to the Board, under cover, addressed to the President, and were accompanied by a letter, stating that I had lost no time in complying with the wishes of the Board respecting the subject of Potatoes, and that the papers which accompanied that letter, contained what appeared necessary for me to say on that head. But, I added, that these remarks were intended solely for the use of the Members of the Board itself, and “were not intended to be *published*.”

This

This I forbade in the most positive manner; and even requested that the Board would be so kind as not to mention my name, in any publication they might think proper to make on that subject; desiring that the papers might be returned to me, after the Members of the Board had satisfied themselves with regard to them. So anxious was I that this requisition should not be forgotten, that I mentioned it no less than three times, in as many different letters I had afterwards occasion to write to Sir John Sinclair; and as the franks had been reduced in weight before the last letter was written, I desired him, with a view to avoid the trouble of addressing so many covers as it would then require, to send the MS. to my son in London, who would take care to get it forwarded to me. After all this, the reader will judge of my surprise, when I read these words in a letter from Sir John: ‘The Board has at length finished its publication, on the subject of Potatoes; *and as you have been a contributor to it*, you are entitled to a copy of it.’ In what manner I had become a contributor to that work, I could not well conceive;

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conceive;

conceive ; for I did not then imagine, that ever he could think of publishing what I had so positively forbidden : but as some observations of mine on Potatoes had been printed in other publications, I thought something might have been extracted from these works, to which this passage might allude. I took the earliest opportunity that offered, to consult that work for my own satisfaction. My astonishment at seeing the observations printed entire, with all their faults, and others superadded, and thus forced upon the public notice, “ unanointed, unanelled ;” and the indignation I felt at this unexpected insult, may be easier conceived than expressed. I call it an insult, because I conceive that no one acting in the character of a gentleman, can have a right to publish the writings of another, even without his consent, far less, if contrary to his express injunctions, clearly announced, and repeatedly enforced. You, Sir John, have it in your power, by publishing my letter, to correct, me if I misrepresent the fact. If I have stated it justly, it is incumbent upon you to make such an apology, as one gen-

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tleman

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tleman ought to give, and another to receive.

What adds *injury* to the *insult*, on the present occasion, is, that from the whole tenor of the writing, it was obviously intended for private information only, and not at all for the public use; and if you had taken the trouble to read, with an ordinary degree of attention, the first sentence only, you could not have failed to perceive it. You need scarcely be told it may be extremely proper to express in a particular way, what was obviously calculated for the private perusal, of a few gentlemen only, who were about to judge of matters that were not within the sphere of their observation; though it would be exceedingly preposterous to make use of the same expressions, when intended to be laid before the best-informed professional men in the kingdom. The observations which, in the one case, would only be calculated to induce that cautious circumspection which men of professional knowledge, in any line, are in some measure required to use, when called upon to assist  
those

those of less experience, whose situation in life incidentally may bring them to decide in matters respecting that profession; but, in the other case, as being addressed to professional men, many of whom may be supposed, to be equally well informed as the writer himself, could be considered as little better than an insult, and would indicate an overweening presumption in the writer, that could only excite disgust and contempt. Such, in fact, is precisely the case in the present instance; and the words of the introductory paragraph to that Essay, if they were supposed to be intended for publication, can only be calculated to make an impression on the mind of every reader, that is very little in favour of the writer; and what I conceive to be extremely different from what my own character, if not obscured under such an humiliating disguise, ought naturally to produce. I feel, at least, that if any other person had written such a paragraph, intending it to be published, as this has been, I should have despised him as an impudent coxcomb, whom it would be a merit to humble. Sir John Sinclair, is

as capable as any man of judging of the irresistible effects of such impressions on the public mind; nor would there have been any thing extraordinary in it, if he had, on receiving such a paragraph for publication, from a man with whom he was in habits of intimacy, requested him to reconsider it, to see how far he thought it proper for the public eye, on the supposition that it had escaped his notice through inadvertency. But to publish it in that imperfect state, though contrary to the express orders of the writer, repeatedly enforced, without giving him even a hint of such an intention, was using a freedom, which no man, whatever his situation in life may be, has a right to take with another. The law has provided a punishment for him who injures his neighbour's good name. The injury may be as great when it is done in this way as any other, though it has, perhaps, hitherto escaped the notice of legislators. With those who shall read this letter, perhaps, *a part* of the injury may be done away; but Sir John ought to consider that thousands may have seen the publication alluded

luded to, who may never have an opportunity of reading this, and that the writer must continue to be despised by them till the end of time.

Besides the circumstance above alluded to, there are other blameable particulars, originating from the publication of that performance, by the Board of Agriculture, that must affect the character of the writer; for so little attention has been paid to the printing, that from the incorrectness of the press, he must, in some cases, appear to write in a manner altogether unintelligibly, and, in others, he is made to speak perfect nonsense\*. I will not say that these things were intended: But is it fit that one person should suffer a material injury, through the carelessness of another; especially when that is produc-

\* EXAMPLES. I had said, 'But now *that* fresh kinds are obtained from *seeds*,' which is printed, 'But now *the* fresh kinds are obtained from *reds*.' I had said, 'Nor are those kinds that send their bulbs deep in the ground, so *destrable* as those that rise upwards,' which is printed, 'so *durable* as those that rise upwards.' I had said, that in a rich mellow soil, 'the roots would be able to strike with ease, and *find* abundant nourishment;' it is printed, 'and *send* abundant nourishment.'

## 38. ON DRAINING BOGS

ed, not in the ordinary course of business, but is occasioned entirely by the culpable forwardness of that person ?

I am happy at being now come nearly to the close of a letter, the writing of which has been to me a very unpleasing task ; for I mean not to bring forward any other complaints against you, at this time ; and hope I never shall be forced to do so, at any future period. I do not take pleasure in finding fault ; and in few cases could it prove more irksome to me than the present. Anxious as I have been, through the whole course of my life, to see the prosperity of this country augmented, by promoting the peaceful exertions of rural industry, and thus preserving the morals of the people untainted, the only sure basis of national welfare ; I cannot but feel a sensible regret, at any degradation of the character of the man who has taken the lead, for the present, in that laudable undertaking. Undoubtedly, nothing tends so much to exalt a man's character, and to give him superior weight on all occasions among his equals, as that unbiaſſed integrity, which, rising  
above



above those partialities and prejudices that are inseparable from little minds, presses steadily forward in its course, without wavering, however assailed by the tempting lures that may be held out to it, on either hand, by the artful and designing. It was this that raised Aristides, the Athenian, to that exalted pre-eminence which suppressed even competition itself, and gave him singly the power of adjusting the claims of rival states. Such a character commands respect, even where talents are rather defective; and will make errors themselves be overlooked by most men: but where this divine attribute is wanting, the most brilliant talents display their lustre in vain; and even the most useful pursuits, by such men, are frustrated. I have been hurt, Sir John, at the obvious partiality of your conduct towards myself, and the apparent design, unfairly, to lessen my character with the public. Should a similar weakness, to use the mildest expression, be perceived in regard to others, the influence of the Board of Agriculture must soon be lost with the public. It will only be then viewed as one of

those tiny institutions, that are calculated to soothe the vanity, or to augment the political influence of certain individuals for the time. I most anxiously wish that this may never be the case ; and shall only add, that if any thing I have here said, shall, by inducing a little more circumspection, where the reputation or the interest of others may be affected by any casual inattention on his part, tend to render the character of Sir John Sinclair, still more respectable than it has hitherto been, it will add to the pleasure and happiness of

Sir,

Your very sincere well-wisher,  
*JAMES ANDERSON.*

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Whether it was in consequence of the demand above made, or from any other motive, the author cannot say ; but in the news-paper called the *Sun*, for June 3, 1796, the following account of Mr. Elkington's mode of draining was published. As soon as he heard of it, the author took the earliest opportunity of reading it, which  
 he

he had no sooner done, than he repented him of having, in some measure, pledged himself in that letter, to make some remarks upon it. Writing, where one finds little to commend, is but a very unpleasing task. On the present occasion, it became peculiarly so, because the honest man, against whom would seem to apply, any censure that should be made, appears himself to be abused.—No wonder, then, if the task was undertaken with reluctance, and as long delayed as possible. When about to publish the present edition of these Essays, however (Feb. 1797) the author thought it incumbent on him, after what had passed, to take some notice of this publication ; and with that view, he read it over with greater care than he had done before, which enabled him to perceive, that he could happily get rid of the task ; for, unless it be in a very few particulars indeed, he finds, that from the most painful attention he could bestow upon it, he has scarcely been able to collect a single consistent idea from the perusal of that performance.—At the first cursory reading, he believed, indeed, that he should be able

able to make something of it; but afterwards he found, that in proportion as the passages were examined with care, these nascent ideas evanished. He now, therefore, is forced candidly to acknowledge, that he cannot collect, *from this paper*, any thing that can decisively show, whether Mr. Elkington's mode of draining be the same, or different from his own. That the reader may judge for himself, however, in this case, and that the present Treatise may be made as complete as possible on this subject in itself, that paper (which is not very long) is printed entire, with as strict an attention to accuracy as he could bestow. It is, however, so far fortunate for Mr. Elkington, that it does not appear to be written by him. Indeed, it bears internal evidence sufficient to prove, that it never could have been written by him, or by any one who had actually *practised* draining.

MR. ELKINGTON'S MODE OF DRAINING.

EXTRACTS *from the* MINUTES *of* PROCEEDINGS *of the* BOARD OF AGRICULTURE, *respecting* Mr. ELKINGTON'S *Mode of Draining Land.*

“ It is a circumstance hardly to be credited, that the principles on which the draining of land depends, should have remained so long unascertained, considering the great private benefit, and the many public advantages, which must necessarily be derived from carrying so important an art to perfection.

“ The following narrative will explain the circumstances, that led to so valuable a discovery ; which, however immaterial in themselves, it was thought right to preserve, as a proof, among many others, how trifling incidents may produce very important consequences :

“ About 30 years ago (anno 1763-4) Mr. JOSEPH ELKINGTON, then 22 years of age, took a farm, called Princethorp, containing nearly 200 acres, situated in the parish

rish of Stretton upon Dunsmore, in the county of Warwick.—The parish had been lately inclosed by act of parliament, but the farm he possessed consisted chiefly of poor quality, not being worth more than six shillings per acre. It was extremely wet; and finding that it rotted his sheep, he determined, if possible, to drain it.—The field in which he began was of a wet, gravelly nature, and full of springs. In order to drain it, he dug a trench, from four to five feet in depth; but after proceeding with it for about 100 yards, he found that no water entered the trench, and consequently that he had not hit upon the spring which occasioned the mischief. A thought accidentally struck him, that it might be of use to know what kind of strata lay under the trench, whether hard or soft, and how near it lay to the rock. He got an iron-crow, or bar for that purpose, about 18 inches in diameter (such as the Warwickshire farmers commonly make use of for making holes, into which their stakes for fixing hurdles are put). This crow he forced down about three feet into the earth. Upon  
taking

taking it out, to his astonishment, a great quantity of water burst out, and ran down the trench.—This naturally led Mr. Elkington to think of applying an auger, as an instrument better adapted for the purpose of boring. Upon trial, he soon found that to be the case; and by following the same plan, using the auger where necessary, he was at last enabled to drain all the wet parts of his farm\*.

“ The

\* This account of Mr. Elkington's discovery, differs in nothing materially from that which is stated in my letter; only it appears, that the precise date of this supposed discovery, seems to be carefully kept out of view. It is here said, that he *took his farm* (observe, it is *took* his farm, not that he *entered* to it, far less that he made his discovery in draining) in the year 1763-4. For aught that here appears to the contrary, he may have entered into the possession of his farm, in the year 1774: for I have known many leases of farms *taken ten or twelve*, some *twenty* years before the entry to them. But to put aside all appearance of cavilling, let us suppose that the ambiguous date of 1763-4, means that he *took* it in 1763, and entered to it 1764. I take particular notice of this circumstance here, because, in the answer Sir John Sinclair wrote to my first letter, printed above, after apologizing to me, for having obtained a premium for Mr. Elkington, instead of myself, he seemed to consider the priority of the date of Mr. Elkington's

“The advantages attending the draining of this farm, were very great indeed. Elkington’s discovery, as the ground on which he must determine. “I am to meet with him (says he) at Wooburn Abbey, on Monday next, when I shall have this circumstance fully investigated, and inform you of it.” The publication above, is the first intimation I had of it. Now, by what is here said, it could not be earlier than the year 1764; probably it must have been many years after—for it is said, the farm rotted his sheep, which he could not know, till he had been in possession of it at least one year. From the very next paragraph it appears, that he had not kept it one year only, but several years before he began to drain; for it is there said, “when he first got possession, he lost, *in the course of a few years*, above 800 sheep by the rot.” The original discovery, therefore, must have been made by him, not in the year 1764 or 1765, but several years, at least, posterior to these years. Whence comes it, that Sir John should now *studiously* speak with so little precision, to a point that he confessedly considered to be of a most primary importance. I, for my own part, consider it to be of no consequence who made the discovery, if discovery it must be called; for I doubt not, but it had been made by others long before either Mr. Elkington or myself was born:—but a man ought to be consistent with himself. Such disingenuous shifts, to disguise truth, excites contempt for the meanness of the person who adopts them, rather than resentment for the injury intended by them. Through every paragraph in this paper, the same disingenuous effort is clearly discoverable: Might it not be said, in this instance, “the spirit is willing, but the flesh is weak?”

When



## AND SWAMPY GROUNDS. 47

When he first got into possession, he lost, in the course of a few years, above 800 sheep by the rot; whereas, since the farm was completely drained (one season alone excepted, when a field that had not been particularly attended to, rotted about a score) his flock has never been affected by that disease."

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### *On the Principles of Mr. Elkington's Mode of Draining.*

"WETNESS of land, in so far as it is connected with the present enquiry (for it is unnecessary, on this occasion, to take any wetness into consideration, if occasioned by the overflowing of the sea, or of lakes, or of running water) must either proceed from rain-water lying on the surface, or from springs issuing from below.

"No water will remain upon the surface, but upon clay, or where the substratum is clayey, for through the more porous soils it naturally subsides. Clay, however, being of a tenacious nature, water can  
4 neither

neither pass through it from the surface to the bottom, nor from the bottom to the surface. In such land, therefore, there can be no springs, and the water that falls on the surface must remain upon it, unless there is a descent, and the water is carried down by surface-drains, or until it is exhaled by the air, or by the sun.

“ Where the surface does not consist entirely of retentive clay, but is porous above, though tenacious below ; the Essex or Hertfordshire mode of hollow-draining may be successfully practised.

“ The object of Mr. Elkington’s system, however, is, the draining of lands rendered wet by waters confined beneath the surface, and attempting to rise in the manner of springs. It is necessary, therefore, in the first place, to ascertain the nature of springs.

“ According to Mr. Elkington’s idea, springs originate from rain water, saved and collected by the hills and rising grounds ; which water subsides through particular strata, and runs either over or under such other strata as are impervious to water ; according as they happen to lie,  
when

when the water comes into contact with them. He also supposes, that there must be great quantities of water preserved in the bowels of the earth, either in a few or in many reservoirs, according to the extent of which, springs are either temporary, (flowing only in wet seasons, and in general bursting out on the sides of hills) or perpetual, which are chiefly to be found at the bottom.—Where the quantity of water is great, and the orifice or channel small, the water must necessarily flow in equal abundance, at all seasons of the year.

“ Springs, he divides into two sorts:—**Land-springs;** which being supplied by a small quantity of ground (perhaps only a single vein of sand or gravel) must soon run dry; and **bog-springs,** which being supplied by a hill, or great tract of country, must necessarily be more regular and abundant.

“ In regard to the regularity of bog-springs, it is to be observed, that whatever may be the quantity of rain that falls upon a hill, and subsides through its porous soils, or through the fissures of the rocks, and then falls into reservoirs; yet the

quantity of water that issues at the spring, in any given space of time, must depend upon the size of the orifice, at or near its mouth; and the velocity with which it flows, is according to its descent from a greater or lesser height.

“ There are only four substances through which springs naturally issue; namely, 1. Rock, whether consisting of stone or hard chalk; 2. Gravel; 3. Sand; and, 4. Marle.

“ When springs issue through clay, it can only be in consequence of the clay being perforated, and upon this circumstance, in a great measure, depends the success of Mr. Elkington's mode of draining; for the wetness of land, arising from subjacent water, is in general occasioned by this, that the water runs under a stratum of clay, until it comes either to rock with fissures in it, or to gravel, sand, or marle; it then rises, or endeavours to rise, to the surface, and in wet seasons overflows the land thus circumstanced. But if, by perforating the stratum of clay, you can intercept the water, and thus prevent its rising, or can give it an easier channel,  
you

you may then conduct it in any manner that may be thought most advisable, and the land which lies above the bottom of the trench is drained.

“ The object of Mr. Elkington’s system, therefore, is that of draining land injured by subjacent waters, not by using palliatives, but by obtaining the command of the subterraneous waters themselves, and thus completely, and radically, cutting off the cause of the mischief. Where there is only one collection, or one principal vein, with several smaller ones, this may be done as effectually by one drain as by a thousand.

“ The different kinds of soils in which Mr. Elkington has principally worked, are, 1. Clay; 2. Sand; 3. Bogs, or Morasses.

“ In many parts of England, there are veins of sand, where the ground is of a clayey nature, and where the soil is commonly called clay, because that substance predominates. In such a soil it is very difficult to work, as it requires a number of trenches, because there is no general mass, but only partial collections of water.

The water is collected in beds of sand or gravel, which, perhaps, may have no communication with each other, being crossed and intercepted by beds of clay; and, consequently, as many trenches must be cut as may be necessary to extract the water from every bed of sand or gravel, each vein of which, if surrounded by beds of clay, becomes a separate reservoir of water; at the same time, there is no impracticability in draining land of that mixed description, though it requires more pains and attention. In this mixed sort of soil the ordinary modes may be successful.

“ It is also difficult to drain any field where sand predominates, as the water subsides through it. In land of that description, it is better that the drain should be open, and also very wide, that it may not easily fill up.

“ But the great object of Mr. Elkington's system is that of draining bogs; and it is in every point of view the most important; because, in the first place, immense tracts of valuable land, of a morassy nature, are lost to the community,  
from

from an idea, that it is impossible to drain them : and in the second place, because land of that nature and value, in proportion to its extent, can be drained at the smallest expence, and when they are drained, are, perhaps, the most valuable of any.

“ When a bog or morass is to be drained, the first object is, to ascertain the direction in which the trench should be dug. This is the most difficult part of the whole business, as it is hardly possible to explain it by words or writing, owing to the great variety of bogs, and the great diversity of countries in which they are situated.— No man can acquire this art completely without a great deal of practice. Such rules as Mr. Elkington has been able to furnish, are as follows :

“ 1. As the whole depends upon the nature of the bog to be drained, and the state of the adjacent country, as much knowledge as possible must be obtained respecting the strata in the neighbourhood, whether consisting of stone, gravel, sand, or marle, as the water must be lodged in one of these, and it is necessary to ascertain which.

“2. The trench must be directed so as to hit the bottom of the bed which occasions the mischief, and the particular spot where the main spring lies. One spring probably occasions the whole bog, which having no proper vent, forces the water through a number of small veins, even to a great distance, and makes the whole a swamp. By draining that main spring, the others follow of course.

“3. If there are various beds through which water issues, the stone is the one to be preferred for draining the whole, as the water is much more easily drawn through it, than through gravel, sand, or marle; consequently, by draining the spring there, the whole water which communicates therewith flows through it; water always preferring a straight or clear to a crooked channel. But in stone beds, the trench ought to be made from six to eight yards from the tail of the bed, or the place where the rock ends; because, in limestone, and in other rocks, the tail, as it is technically called, is harder than any other part of the rock, and there are few, if any, fissures in it; but by going a few yards



yards above, you get into a softer part of the bed, and the water is more accessible. The tail of these beds may often be found in a point or promontory, jutting out from the adjacent heights.

“ 4. The trench, in general, should be directed in a line with the bottom of the Hill, because it makes the best separation between the Upland and the Meadow Inclosures, and the spring can best be intercepted. The trench, however, must be carried in the line of the spring, or near it; for if it diverges from it at any distance, all prospect of reaching the spring, by tapping it; or otherwise, is over, and the labour bestowed upon digging it, is probably lost.

“ 5. It is better to make a new trench than to tap the spring in any old brook or run of water, where that may be practicable; for though the spring, when once it bursts out, has force enough to throw up any stones, sand, &c. that may accidentally fall into it, yet brooks, in a flood, may bring down such immense quantities of sand, &c. as completely to overweigh and choak up the spring, and so much caution

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is necessary to prevent any risk of such a circumstance, that when the trench crosses any runlet of water proceeding from a small brook, or from a collection of surface water, the trench is puddled, so as not to receive it, lest it should blow up, and destroy the works.

“Lastly, having fixed on the general line of direction, and marked out the trench, you are to begin at the bottom or lowest level, carrying your trench gradually up, the spirit-level in this part of the operation being your guide. The fall for the water need not be very considerable; a few inches in a hundred yards will be sufficient.

“In digging the trench, no tools but those of the most common sort are made use of, and common labourers can carry on the trench, under an experienced foreman or overseer. The auger, which must often be made use of for tapping the spring, may be from one and a half to two inches diameter, and is applied in the ordinary manner. If, in boring, a stone is met with, the auger must be taken off, and a chissel  
or.

or punch screwed on, to penetrate so hard a substance.

“ Sometimes the spring is cut off by the trench alone; but in many cases it lies greatly below the level of the trench, in which it is necessary to make use of the auger, for tapping the spring, as it is called. Mr. Elkington bored an auger-hole near Tamworth, thirty feet in depth, which threw water up equal to three hogheads in a minute, and completely drained all the neighbourhood.

“ To judge when to make use of the auger, is a difficult part of the business; and here it is to be observed, that if the water, from having a straight and clear channel, rises without difficulty through the hole made by the auger, it may draw off the spring above, and even drain all the neighbourhood, and you may proceed no farther. For natural springs often issue through narrow and crooked perforations, and, consequently, the water may prefer the easier though lower orifice. If it is certain that all the water in the spring flows through the hole made by the auger, you may there stop; if not, the trench must

must be carried farther, and the auger again made use of.

“ The trench being once made, and the spring cut off, either by tapping or otherwise, it is then necessary to determine whether the drain should be open or covered. If the drain can with propriety be made a fence at the same time, it had better be open, if not, it ought to be covered. No apprehension need to be entertained of the holes made by the auger being filled up, whether the drain is open or covered, unless other waters are admitted; because such is the force of the spring, that it will throw up any stones, earth, or other substances that might accidentally get into it, and it can be injured by nothing, but great quantities coming upon it at once.

“ If the drain is to be covered, the mode adopted by Mr. Elkington is, to make it square, either of common brick or stone. Of the two, stone, when flat, is preferable; at the same time, when stone cannot be had, a sort of brick, invented, it is said, by Mr. Elkington, answers the purpose well.

“ But

“ But the tax (which certainly ought to be taken off, on bricks for drains) prevents the general use of this article, though so well calculated for the purpose. If the drain is well made, it may last for ages; the force of the running-water preventing it from filling up, more than a spring flowing through the bowels of the earth, provided the mouth of the drain is kept open, and regularly cleaned out when necessary. None of those made by Mr. Elkington have as yet failed; any person who makes in future, may safely engage to keep them in repair for fifty or one hundred years.

“ This system of draining land is sometimes attended with extraordinary consequences. By it, not only the land below the natural spring, or even above the artificial spring, is drained, but the waters from the neighbouring heights, finding a new and easier channel, abandon the places to which they formerly went, and thus a tract of country may be drained, without the least apparent communication with the spring intended to be drained, or the trench made to it. Nay, a drain made on one side of a hill has been known to  
make

make springs and wells on the other side quite dry, opening a channel of an easier sort, to which the water naturally draws.

“As yet, Mr. Elkington has only made use of these discoveries for the purpose of draining the land. But as the complete command of an unexpected treasure of water is thus obtained, it is probable, that the plan may be very much improved, by using the water thus obtained for the purpose of flooding land, which it is well known is the greatest of all improvements, as it requires little pains or expence to insure, by means of the water alone, luxuriant crops and perpetual fertility. From springs also such quantities of water may be obtained, as may be of use in regard to mills and navigations, and in supplying private houses, and even towns and villages, with wholesome water to drink, or to use for other purposes, instead of mere puddle.

“Mr. Elkington being extremely successful in judging of the strata of the earth, where it has not been greatly altered by some convulsion of nature, it may be right to state the principles on which he acts.

His

## AND SWAMPY GROUNDS. 61

His mode of judging of the strata is not from the herbage that grows upon the surface, which is often artificial, and not natural (rushes only excepted, which denote clay) nor, as some imagine, from the morning and evening vapour; but in wet weather he judges by the state of the surface, the veins of clay being then wet, whereas those of sand are comparatively dry. The best mode of determining the matter is, however, by examining the neighbouring heights, particularly if any pits or quarries have been made in them, because, if the one height at all resembles the other, the strata on the same level will probably be the same. He also judges, with remarkable precision, how to find stone in places where it would not be generally looked for, and to discover the place where wells may be made with the best chance of success.—The rules on which he acts in regard to these two articles, must be the subject of future enquiry. The knowledge of the different strata will be greatly facilitated by Mr. Elkington's giving plans of the strata in England, so far as he has travelled through it; the  
same

same strata frequently running in a line from sea to sea.

“ On the whole, it appears that this mode of draining land injured by subterraneous waters, is by far the most effectual of any that has yet been suggested; and, to the credit of Mr. Elkington, it is to be observed, that he made no difficulty in communicating the nature of his discoveries to the Committee of the Board of Agriculture, appointed for the purpose of meeting with him upon the subject; and that he left it entirely to the Board to make him any remuneration, or not, as they might judge proper.

“ Mr. Elkington having thus enabled the Committee, to form some idea of his system of draining, and the principles on which it is founded, it only remains to point out the best mode of making others masters of the subject, so that the benefits thereof may be spread as quickly as possible over the kingdom. Mr. Elkington is of opinion, that the most likely plan for that purpose, is, for the Board either to pitch upon some intelligent persons to travel about with him, to whom he will communicate



communicate his ideas, and explain the principles on which he acts more distinctly, by pointing out on each spot, respectively, the manner in which he would drain the different kinds of soil; or to bind apprentices to him, whom he would readily instruct. Perhaps, a tour over the whole island, would be adviseable, beginning with the Eastern, and returning by the Western coasts of the kingdom. Mr. Elkington would thus be enabled to judge, to what extent this mode of improvement could be carried, and whether the same system will answer amidst the hills and vallies of Wales, or Scotland, as in those of Lancashire, where he has already been so successful."

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The only remark I shall make on the above is, that it is not easy to form an idea how such a performance could ever have been produced. Perhaps, it may be accounted for on the supposition that the following case could have happened.—If Mr. Elkington, when he met the Committee of the Board of Agriculture at Wooburn-Abbey,

Abbey, for the purpose of explaining to them the principles of his mode of draining, should have candidly told them, that he was merely a plain practical man, who was little acquainted with philosophical principles of any sort, and therefore was not able to give any kind of explanation such as they seemed to require ; that he could not clearly express, perhaps, any of his ideas, so as to make them intelligible to gentlemen of their rank ; but, if they would have the goodness to show him a field that required to be drained, he would let them see in what manner he should proceed, and give them the best explanation he could of every thing about which they should interrogate him as he went on ; and that this was the only way in which he thought he could make the reasons of his practice be fully understood. Should this, I say, have happened, and should this have been all the information the Committee could obtain from himself ; and should they farther think, that after what had happened, it would be absolutely necessary for the Committee to make some *report* to the Board ; and should they

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they thus circumstanced, have charged some person to make out the best account *he could* on this subject; and should that person, who had formed a few vague notions from the imperfect hints of Mr. Elkington ill understood, and mingled with former ideas adopted at school, make out that account; such a production as that which has been above exhibited, might naturally enough have been the result.— I do not say, that this did actually happen; but, I think, it would be difficult to account for such a performance in any other way. It certainly never could have been written by one who had even *attempted* to put his own directions into practice.

In the present edition some additions have been made to this Essay, to render it somewhat more complete than before; but these additions are carefully distinguished from the original performance. These additions, with some others, are printed separately, to be sold for the accommodation of the purchasers of the former editions of this work: and for the sake of other purchasers, who may incline to have the Essay on Draining complete, that Essay

has been there given entire. To which is added, the Two Letters to Sir John Sinclair, illustrative of that subject.

It is hoped, the author will be pardoned for employing the same plates for the separate publication as for the book, though they contain some objects that do not relate to the present Essay.

## AND SWAMPY GROUNDS. 67

ON

DRAINING BOGS

AND

SWAMPY GROUNDS.

**I**N the preceding Essay, I have showed, that water may on some occasions be of great utility to the farmer; yet, as there are few things more prejudicial to him than a superabundance of it, when too long continued upon the ground, it behoves him to guard against this evil as much as he possibly can; and at almost any expence, to free his ground from it, if he hopes to make any considerable improvement thereon; for, unless this be first done, all his other operations will turn out to little account.

The methods of drawing off stagnant water, which may be accumulated in any low situation, for want of a proper outlet, are in general so obvious to every man of discernment, who examines the situation of the ground, that I shall not tire the

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reader by enlarging upon that head ; but shall proceed immediately to treat of the most proper method that I have experienced, of draining such ground as is hurt by springs oozing out upon them (usually distinguished by the name of *wet*, or *spouting* ground) and bogs\* ; as this is a matter of much greater difficulty than the former, and the principles upon which it should be conducted, far less generally understood.

Springs are formed in the bowels of the earth, by water percolating through the upper strata, where they are of a porous texture, which continues to descend downwards, till it meets with a stratum of clay that intercepts it in its course ; where, being collected in considerable quantities, it is forced to seek a passage through the porous strata of sand, gravel, or rock, that may be above the clay, following the course of these strata till they approach

\* It will appear to the reader, that the term *bog*, is here employed in its most unlimited acceptation, denoting any kind of quaggy ground arising from too much moisture ; and not according to the usual meaning of the word in Ireland, where it, for the most part, only denotes what is in Scotland called peat-moss.

## AND SWAMPY GROUNDS. 69

the surface of the earth, or are interrupted by any obstacle which occasions the water to rise upwards, forming springs, bogs, and the other phænomena of this nature; which being variously diversified in different circumstances, produce that variety of appearances in this respect that we often meet with.

This being the case, we may naturally conclude, that an abundant spring need never be expected in any country that is covered to a great depth with sand, without any stratum of clay to force it upwards, as is the case in the sandy deserts of Arabia, and the immeasurable plains of Lybia. Neither are we to expect abundant springs in any soil that consists of an uniform bed of clay from the surface to a great depth: For, it must always be in some porous stratum that the water flows in abundance, and it can be made to flow horizontally in that only, when it is supported by a stratum of clay, or other substance that is equally impermeable by water. Hence the *rationale* of that rule so universally established in digging for wells, that if you begin with sand or gravel,

vel, &c. you need seldom hope to find water, till you come to clay; and if you begin with clay, you can hope for no water in abundance, till you meet with sand, gravel, or rock.

It is necessary that the farmer should attend to this process of nature with care, as his success in draining bogs, and every species of damp and spouting ground, will in a great measure depend upon his thorough knowledge of this,—his acuteness in perceiving in every case, the variations that may be occasioned by particular circumstances, and his skill in varying the plan of his operations according to these. As the variety of cases that may occur in this respect, is very great, it would be a tedious task to enumerate the whole, and describe the particular method of treating each; I shall, therefore, content myself with enumerating a few particular cases, to shew in what manner the principles above established may be applied to practice.

Let Fig. 21st represent a perpendicular section of a part of the earth, in which AB is the surface of the ground, beneath  
which



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which are several strata of porous substances, which allow the water to sink through them till it reaches the line CD, that is supposed to represent the upper surface of a solid bed of clay; above which lies a stratum of rock, sand, or gravel. In this case it is plain, that when the water reaches the bed of clay, and can sink no farther, it must be there accumulated into a body; and, seeking for itself a passage, it will flow along the surface of the clay, among the sand or gravel, from D towards C, till at last it issues forth at the opening A, a spring of pure water.

If the quantity of water that is accumulated between D and C is not very considerable, and the stratum of clay approaches near the surface, in that case, the whole of it will issue by the opening at A, and the ground will remain dry, both above and below it. But if the quantity of water is so great, as to raise it to a considerable height in the bed of sand or gravel, and if that stratum of sand is not discontinued before it reaches the surface of the ground, the water in this case, would not issue at A only, but would like-

wise ooze out in small streams through every part of the ground, between A and *a*, forming a barren patch of wet sandy or gravelly ground upon the side of a declivity: Which is a phænomenon that every attentive observer must have frequently met with.

To drain a piece of ground in this situation, is perhaps, the most unprofitable task that a farmer can engage in; not only because it is difficult to execute, but also, because the soil that is gained is but of very little value. However, it is lucky that patches of this kind, are seldom of great breadth, although they sometimes run along the side of a declivity, in a horizontal direction, for a great length.

The only effectual method of draining this kind of ground, is, to open a ditch, as high up as the highest of the springs at *a*, which should be of such a depth as not only to penetrate through the whole bed of sand or gravel, but also to sink so far into the bed of clay below, as to make a canal therein; sufficiently large to contain and carry off the whole water. Such a ditch is represented by the doted lines *a*,

*e*, *z*;

*a, z*; but as the expence of making a ditch of such a depth as this would suppose, and of keeping it afterwards in repair, is very great; it is but in very few cases that this mode of draining would be adviseable, and never, unless where the declivity happens to be so small, that a great surface is lost for little depth; as would have happened here, if the surface had extended in the direction of the doted line *a d*.

But, supposing that the stratum of clay, after approaching to the surface at *A*, continued to keep at a little depth below ground; and that the soil which lay above it was of a sandy or spongy nature, so as to allow the water to penetrate it easily; In that case, even supposing the quantity of water that flowed from *D* to *C*, was but very inconsiderable, instead of rising out at the spring *A*, it would flow forward along the surface of the clay, among the porous earth that forms the soil, so as to keep it constantly drenched with water, and, of consequence, render it of very little value.

Wetness, arising from this cause, is usually

usually of much greater extent than the former ; and as it admits of an easy cure, it ought not to be one moment delayed. For a ditch of a moderate depth opened at A, and carried through a part of the stratum of clay (as represented by the dotted lines A, k, f) would intercept and carry off the whole of the water, and render the field as dry as could be desired. It is, therefore, of very great consequence to the farmer, accurately to distinguish between these two cases, so nearly allied to each other in appearance ; and as this can be easiest done by boring, every one who has much ground of this kind, ought to provide himself with a set of boring-irons, which he will likewise find use for on other occasions.

I might here enumerate a great variety of cases which might be reduced to the same head with the foregoing : but as any attentive reader may, after what has been said, be able easily to distinguish these, I shall only in general observe, That every soil of a soft and porous texture, that lies upon a bed of hard clay, whatever its situation in other respects may be, will in  
some

## AND SWAMPY GROUNDS. 75

some measure be subjected to this disease: And if it is upon a declivity of any considerable length, the undermost parts of the field will be much damaged by it, unless ditches are thrown up across the declivity, at proper distances from one another, to intercept the water in its descent.

It may not likewise be improper here to remark, that, in cases of this nature, unless where the soil is of a very great depth, the malady will always be increased, by raising the ridges to a considerable height; as will appear evident by examining Fig. 22, in which the line AB represents the surface of a field of this nature, and CD the surface of the bed of clay. Now, if this field were raised into high ridges, as at F, F, F, so as that the furrows E, E, E, descended below the surface of the clay, it is plain, that all the water that should sink through the middle of the ridge, would run along the surface of the clay, till it came to the sides of the ridge L, L, L, L, L, L, which would thus be kept continually soaked with water; whereas, if the ground had been kept level,

vel, as in the part of the field from G to H, with open furrows H, at moderate distances from one another, the water would immediately sink to the clay, and be carried off by the furrows, so as to damage the soil far less, than when the ridges are high.

If the soil is so thin, that the plough can always touch the clay, the ridges ought to be made narrow and quite flat, as from G to H; but if there is a little greater depth of soil, then it ought to be raised into ridges of a moderate height, as from H to K, so as to allow the bottom of the furrow to reach the clay. But neither is this necessary, where the soil is of any considerable depth.

I have seen some industrious farmers, who having ground in this situation, have been at the very great expence of making a covered drain in each furrow. But, had they rightly understood the nature of the disease, they never would have thought of applying such a remedy; as must appear evident at first sight to those who examine the figure. The success was,  
what

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what might be expected from such a foolish undertaking.

These observations, it is to hoped, will suffice as to the manner of treating wet, sandy, or porous soils. I now proceed to take notice of such as are of a stiff clayey nature, which are often very different in appearance, and require a different treatment from these.

Suppose that (as in Fig. 23) the stratum of sand or gravel, D C, should be discontinued, as at E, and that the stratum above it should be of a coherent clayey nature: In this case, the water that flowed towards E, being there pent in on every side, and being accumulated there in great quantities, it must, at length, force a passage for itself in some way; and pressing strongly upon the upper surface, if any one part is weaker than the rest, it there would burst forth, and form a spring (as, suppose, at A). But if the texture of every part of this stratum were equally strong, the water would squeeze through many small crannies, and would ooze out in numberless places, as between A and F, so as to occasion that kind of wetness  
which

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which is known by the name of a spouting clayey soil.

The cure, in this case, is much more easily effected than in any of the former : For, if a ditch of a considerable size be opened, as at A, towards the lowermost side of the spouting ground, so deep as to penetrate through the upper stratum of clay, and reach to the gravel, the water will rise up through it, at first, with very great violence, which will gradually decrease, as the pressure from the water behind is diminished. And when the whole of the water accumulated in this subterraneous reservoir is run off, there being no longer any pressure upon the clay above it, the whole soon becomes as dry as could be desired ; and continues so ever afterwards, if the ditch be always kept open. This I speak from experience, I having rendered some fields of this kind that were very wet, quite dry, by this method of treating them.

It will hardly be necessary for me here to put the farmer upon his guard, to be particularly careful in his observations,



that he may distinguish between the wetness that is produced from this cause, and that which proceeds from the cause before mentioned: Because the treatment that would cure the one, would be of no use at all to the other.

The attentive observer, likewise, will readily perceive, that if any field that is wet from this cause, admits of being ploughed, it will be in equal danger of being hurt by being raised in high ridges, with the other kind of damp ground before mentioned: For, as the depth of earth above the reservoir would be smaller in the deep furrows than any where else, there would, of consequence, be less resistance to the water in that place, so that it would rise there in greater abundance.

And if, in this case, a farmer should dig a drain in each furrow;—as a considerable quantity of water would rise into them, in some cases, the ground might be improved, or even quite drained thereby, (especially if they should have accidentally reached the gravel in any other place,) although at an expence much greater than ]

than was necessary \*. I take notice of this circumstance, in some measure, to prevent the prejudice that some inattentive observers might entertain against what we said before of this method of draining, from their having accidentally seen some fields that may have been bettered by it.

Bogs are only a variety of this last-mentioned kind of wet ground, and therefore ought, in general, to be drained after the same manner with them. Clay is a substance that strongly resists the entrance of water into it; but, when clay is long drenched with water, it is, in process of time, in some measure, dissolved thereby, loses its original firmness of texture and consistence, and becomes a sort of semi-fluid mass, which is called a bog. And as these bogs are sometimes covered with a surface of a particular kind of grass, with very matted roots, which is strong enough

\* This seems to have been precisely the case, in the first attempt of Mr. Elkington at draining, in which case he *accidentally* penetrated the bed of clay, and reached the pervious stratum below it.

to bear a small weight without breaking, although it yields very much, it is, in these circumstances, called a *Swaggle*.

But whatever be the nature of the bog, it is invariably occasioned by water being forced up through a bed of clay, as just now described, and dissolving, or softening, if you will, a part thereof. I say only a part, because, whatever may be the depth of the bog, or swaggle, it generally has a partition of solid clay between the bog and the reservoir of water under it, from whence it originally proceeds: For, were not this the case, and were the quantity of water considerable, it would meet with no sufficient resistance from the bog, and would issue through it with violence, and carry the whole semifluid mass along with it. But this would more inevitably be the case, if there was at first a crust at the bottom of the bog, and if that crust should ever be broken; especially, if the quantity of water under it were very considerable. And as it is probable, that in many cases of this sort, the water slowly dilutes more and more of this under-crust, I make no doubt but that in the revolution of many ages, a

great many irruptions of this kind may have happened; although they may not have been deemed of importance enough to have the history of them transmitted to posterity \*.

Of this kind, although formed of a different substance, I consider the flow of the Solway moss, in Cumberland, to have been; which, upon the 16th November, 1771, burst its former boundaries, and poured forth a prodigious stream of semi-fluid matter, which, in a short time, covered several hundred acres of very fine arable ground. Nor will any one who is acquainted with the nature of moss, who knows its resemblance to clay in its quality of absorbing and retaining water, and its very easy diffusibility therein, be surprised at this; as, from all these properties, it is much better adapted for forming an extensive bog, and therefore in greater danger of producing an extensive devastation, by an eruption of the water into it,

\* Probably, the eruption which produced Saint Winifred's well, in North Wales, may have been of this sort. *Note to the fourth Edition.*

than

than those that are formed of any kind of clay whatever \*.

If the bog or swampy ground be upon a declivity, the ditch ought to be carried across the field, about the place where the lowest springs arise. But if the surface of the ground be level, or nearly so, as between A and B (Fig. 24) and the springs break out in several places, *q q q q q q*, so as to form soft quagmires interspersed through the whole of the field, it will be of

\* Since the above was written, I find the eruption of Solway-moss was produced in a manner very different from the above. The water which carried it off, insinuated itself between the smooth bed of clay, below the moss, in such great quantities, as, without softening the moss so as to reduce it to the state of a semi-fluid mass, heaved it up, so as to be as if afloat upon the water, which shoved it bodily forward with the current, till it was left, in a great measure, in its natural state, lying above the corn-fields, to the whole depth of the moss. For farther elucidations on the subject of moss, see a Practical Essay on Peat Moss. Robinsons, 1794—

N.B. At the time the present Essay was written, I had formed no distinct idea of the nature of moss; and at the time the Essay on moss was written, I knew nothing of the fact here stated. It affords an additional proof of the truth of the hypothesis there brought forward. *Note to the fourth Edition.*

little consequence in what part the drain is opened; for, if it be dug so deep as to allow the water to rise in it with freedom, it will issue through that opening, and the field will be left perfectly dry.

But as it may frequently happen that the stratum of gravel shall be at a considerable depth beneath the surface of the earth, and as it may be sometimes even below the level of the place into which the drain must be emptied, it might sometimes be extremely difficult to make a ditch so deep as to reach the bed of sand or gravel. But it is lucky for us that this is not absolutely necessary in the present case; because a drain, of two or three feet deep, as at D, will be equally effectual with one that should go to the gravel. All that is necessary in this case is, to sink pits (P) in the course of the drain, at a moderate distance from one another, which go so deep as to reach the gravel. For, as the water there meets with no resistance, it readily flows out at these openings, and is carried off by the drain, without being forced up through the earth; so that the ground is left entirely dry ever after.

I have

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I have likewise drained several fields in this way ; and as I have generally found the appearances pretty much alike, I shall, for the information of the inexperienced reader give a short account of them :

If you attempt to make your pit in one of these soft quaggy places, where the water is found in great abundance, you will meet with very great difficulty in forming it: For, as the substance of which it is composed is a semi-fluid, it will always flow into the hole as fast as you dig it. On this account, I would advise, not to attempt to make the pit in the swaggle, but as near it in the solid earth as you conveniently can. However, if it be pretty firm, and of no great extent, it will be sometimes practicable to make a pit in the soft bog, at the driest time of the year. This I have sometimes practised, which gave me an opportunity of observing the nature of these bogs more perfectly than I otherwise would have had.

In the trials of this kind that I have made, the soft quaggy ground has seldom been above three or four feet deep, below which I have always found a stratum of

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hard tough clay, usually mixed with stones, and so firm that nothing but a mattock or pick-axe could penetrate it: And as this stratum is comparatively much drier than the ground above it, an inexperienced operator will be very apt to imagine that it is the bottom he is in search of.

In digging through this stratum, you will frequently meet with small springs oozing out in all directions; some of them that might fill the tube of a small quill, and others so small as to be scarcely perceptible. But, without regarding these, you must continue to dig on without intermission, till you come to the main body of the reservoir, if I may so call it, that is contained in the rock, gravel, or sand; which I have generally found from two to four feet below the bottom of the swaggle, and which you will be in no danger of mistaking when you come to it. For, if there has been no opening made before that time in the field, as soon as you break the crust immediately above the gravel or rock, the water will burst forth like a torrent, and, on some occasions, will rise like



like a *jet d'eau*, to a considerable height above the bottom of the ditch ; and continue to flow off with great impetuosity for some time, till the pent-up water being drained off, the violent boiling up will begin to subside, and the strength of the current to abate, and in a short time it will flow gently out like any ordinary spring.

Allowing it to remain in this state for some time, the quaggy earth will soon begin to subside, and gradually become firmer and firmer every day ; so that in the space of a few months, those bogs that were formerly so soft, as hardly to support the weight of a small dog, will become so firm, that oxen and horses may tread upon them without any danger of sinking, at the very wettest season of the year.

I had a field of this nature, that, by having only one such pit, as I have now described, opened in it, was entirely drained, to the distance of above a hundred yards around in every direction.

But, as it is possible that the stratum in which the water runs, may be in some places

interrupted, it will be in general expedient to make several of these pits, if the field is of great extent; always carrying the drain forward through the lowermost part of the field, or as near the quag as you conveniently can; and sinking a pit wherever you may judge it will be most necessary. But if the stratum of gravel is not interrupted, there will be no violent burst of water, at opening any of these after the first, as I have frequently experienced.

To keep these wells from closing up, it is always expedient to fill them up with small stones immediately after they are made, which ought to rise to the height of the bottom of the drain.

I have often imagined, that the expence of digging these pits might be saved, by boring a hole through this solid stratum of clay, with a large wimble (auger) made on purpose; but as I never experienced this, I cannot say whether or not it would answer the desired end exactly.

If the whole field that is to be drained, consists of one extensive bog, it will require a long time before the whole work can be entirely finished; as it will be im-  
possible

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possible to open a drain through it, till one part of it be first drained, and becomes solid ground. In a situation of this kind, the undertaker, after having opened a drain to convey the water from the lowest part of the bog, must approach as near to the swampy ground as he can, and there make his first pit, which will drain off the water from the nearest parts of the bog.

When this has continued open for some time, and that part of the bog is become so solid as to admit of being worked, let him continue the ditch as far forward through it as the situation it is in will admit of, and there sink another pit; and proceed gradually forward in the same manner, making cross cuts where necessary, till the whole be finished.

In this manner, may any bog or tract of spouting ground, of this nature, be rendered dry, at a very inconsiderable expence. And as there can be no other method of draining ground of this sort effectually, I recommend the study of it to the attention of every diligent farmer who may have occasion for it. Let him first be extremely  
ly

tions of a warm imagination, I shall content myself with having pointed out this evil to those who may have it in their power to examine into the causes of this particular malady, and to point out to others the easiest and most efficacious cure.

*Here ends the Essay, as it was originally printed.*





ADDITIONS

TO THE

ESSAY ON DRAINING,

MADE IN THE YEAR 1797.

I AM no longer restrained by the considerations which influenced me when this Essay was first published; an experience of more than twenty years farther has removed those scruples entirely: And though the attentive reader will find little in what follows that may not be inferred from what has gone before, yet it will not perhaps prove disagreeable, to see how the few simple principles above succinctly developed, may be easily applied in some practical cases which assume a considerable diversity of appearance.

The peculiar species of wet land, that has been just now described, is not in general occasioned by springs; for in the kind of soil here described, springs, properly so called, are rarely to be found;—it originates, for the most part, entirely from water that falls from the clouds. When rain falls in  
abundance

abundance upon a field of the kind here described, a part of the water will find its way along the surface towards the furrows, if any such have been made in it, by which it will be carried off the field; but a considerable quantity of water will be absorbed by the porous soil on the top, through which it will gradually sink, till it reaches the solid bed of clay below, which, having never been opened up effectually, resists the water, which can there penetrate downwards no farther. In that case, it can find no outlet until it forces its way laterally towards the furrows, slowly through the superficial mould—or, if no furrows are provided to carry it off, it must remain as in a basin, in which the superficial soil is mixed with the water, so as to become a thin paste, that must remain of a soft consistency during wet weather, and which, when much rain hath fallen, will be only a small degree removed from fluidity—While in this state, it must be highly prejudicial to the vegetation of all those plants we are in the use of cultivating in this country: But in this state the soil must remain, drenched with water, until the return of dry weather. The sun will then evaporate



evaporate it; when the soaked paste, now deprived of its moisture, will assume a hard irony consistence, which is equally unfit for the sustenance of plants as it was in its moistened state.

Such being the causes of this disease, the consequences may be easily removed. The opening up of hollow drains, running diagonally across the slope, at a small distance from each other, if they can be kept open, will answer the same purpose, nearly, that the drawing of open water furrows in the same direction would have done, and will, doubtless, mitigate the evil, in proportion to their nearness to each other: but they must be very close together indeed, if they remove it entirely—for still the soil must be drenched in the manner before described, by the water forcing its way through it, until it reaches the drain.

But, as the rain-water will sink perpendicularly through the soil, until it meets with the solid clay, before it attempts to seek a lateral direction, it must follow that that part of the mould which is nearest to the clay, will be more drenched with water than those parts of it which lie at a  
greater

greater distance above the clay ; of course, the deeper the soil, the less will the surface-mould be liable to be drenched with hurtful moisture.—Hence it follows, that if the soil shall be deepened to such a degree, as that the water, even during the greatest rains, shall not be forced to rise so high as to chill the roots of the plants which grow upon it, the remedy wished for will be effected.

Nor will this be a matter of such great difficulty, as at first sight it might appear—for as the rain sinks slowly downward through such a soil, that portion of rain which falls first continuing to sink regularly, if the soil be mellow, without stopping, goes gradually downward, making way for that which follows, without being regorged back upon it till it meets the bottom—Hence, if we should suppose, for the sake of illustration, that the rain sunk four inches downward in twenty-four hours, and that the rain continued without intermission for three days together, the water would have penetrated, by that time, to the depth of twelve inches, had it met with no interruption before the rain abated ; but  
if

if the soil were no more than four inches deep, the water would have reached the bottom, in twenty-four hours, after which time, it could go no farther—but the rain continuing to pour on more, the soil towards the bottom, by acquiring fresh additions of water every moment, is there soon reduced to the state of a semi-fluid paste; and as the water must rise higher and higher, while the rain continues, more of the soil must be drenched by it, until the whole soil becomes like a soft pap, that is incapable to support the smallest animal. Or, if the open furrows or under-drains be near at hand, a part of the water will at last fall into these, and be carried off the field, after having washed the surface-mould in its passage so as thus to carry off with it all the soluble parts of the manures it has met with in its course. But if the penetrable mould had extended to a greater depth (say sixteen or twenty inches) the water would not stop even when the rain abated, but continue to sink farther, till at last it would be all imbibed by the earth, without having reduced any part of it to the state of a pap—and even without the aid of any drain

whatever. Thus would the mould, having never been reduced to the state of a paste, continue friable, even when dry weather approached: and as the roots of plants growing upon the soil would thus be invited to stretch to a great depth, they would there find moisture sufficient to sustain them, at a time when, if they had been forced to spread abroad near the surface, for want of depth of soil, they must have perished from lack of moisture. In this way, the soil is rendered dry in moist weather, and moist in dry seasons, to a degree that could not otherwise have been experienced. And, as it has been already said, the water in its progress dissolves and carries along with it, a portion of the vegetable manures, this portion of manure, by the process now described, is all left in the soil, and of course tends to meliorate it, instead of being carried off from it either by the water-furrows or the drains, which becomes indispensably necessary, where the soil is thin—and which unavoidably reduces it into that poor hungry state so frequently experienced under circumstances of the sort here described.

There are found in many counties of

Great Britain, immense tracts of poor, hungry, clayey soils, that are all reducible to the class of which we now treat.—They have been denominated *hungry*, from the sudden disappearance of the effects of manures that have been laid upon them; they are also called *hide-bound*, because of the hard stiffness, and miserable appearance of the surface. Few soils are, in their present state, more unprofitable than those. Yet there are, perhaps, none, which, under a judicious management, could be rendered more productive than many of them. It often happens, that over the whole surface of such soils, a thin crop of weakly rushes are produced, while it is allowed to remain in grass; and fog or moss, which establishes itself there during the winter months, is almost the only vegetable production, that gives a sickly verdure to the surface. Upon examination, it will be found, that in all cases of this sort, the unloosened clay rises very near to the surface; in consequence of which, the superficial mould, which has been stirred by the plough, to a small depth only, being thinly spread over it, is subject to be drenched

*through its whole depth* by every violent rain, the manures completely washed out of it, and the whole reduced to a pappy paste, that becomes hard like iron, when the summer heat dissipates the moisture. Under these circumstances, whatever manures or culture are bestowed upon it, are in a great measure, thrown away, as they are seen to produce but very little effect; and these soils, are therefore, in a great measure, abandoned as hopeless.

Many soils of this description, however, if opened to a sufficient depth, may be gradually brought into a state of great productiveness. Indeed, many of the most productive districts in this kingdom consist precisely of soils that were originally of this kind. When such soils are thus opened up, they are, for the reasons above assigned, more effectually drained than they could be by any other process. The manures that are, after this is done, worked into the soil, are never carried off from it, but gradually tend to meliorate, and thus to render more tender and friable, the bottom soil; so as, in time, to become deep, sound, and wholesome land, which is  
neither

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neither strongly affected by the vicissitudes of drought nor of rain.

These effects, however, are not to be expected to be felt at first, to their full extent. Some clays are so cohesive, that mere digging alone will not render them as permeable by water, as could be wished. Before they can become sufficiently friable for the purpose, to the highest degree that could be wished, manures must have had time to operate upon them. For this reason, although the effect of deep digging, and copious manuring, will be at once sensibly felt, yet the melioration that will result from this process, will be going forward for many years to come; and, by degrees, it will be coming nearer and nearer to that highest degree of productiveness for which the old lands of that description, above named, are so very remarkable.

We have an opportunity of observing the effect of thus opening the soil to a great depth, in our gardens, which, in consequence of being universally trenched over, as an initiatory step, are found to continue healthfully dry, even in soils of

this kind, without the aid of either water-furrows, to carry off the surface-rain, or hollow-drains, to carry off the moisture from below. If there be but one drain leading from the lowest part, to allow the little water that *seeps*\* down to it, to be carried freely away, that is quite enough to preserve the mould healthfully dry. But in fields where the plough can penetrate to a much smaller depth, it is found universally, that many water-furrows are absolutely required, before such a soil can be prevented from sustaining great damage from the pasting process above described; and that hollow-drains are likewise required to aid them, before the ground can be made tolerably healthful.

I may be permitted to observe, however, that in most cases of this sort, where the surface-mould is no deeper than the plough goes, hollow-draining becomes necessary only in consequence of the ridges being laid in an improper direction; for, when the furrows lie directly up and down

\* Is *seeps* an English word? It means to flow gradually, and in very small quantities through some resisting medium.



the declivity, it is easy to observe, that whatever water sinks through the mould, will have a tendency, when it reaches the clay, to run forward among the soil towards the bottom of the hill, rather than to force a passage for itself laterally towards the furrows.—In consequence of this, the soil, especially towards the middle of the ridge, in particular where the declivity is considerable, will be drenched with water nearly as much as if no water-furrows were left in the field. To intercept that water therefore, in its descent, hollow-drains, that run asslant the ridges, become absolutely necessary.—If the furrows had been laid in the same direction with the drains, nearly the same benefit would have resulted from the furrows as the drains afford. And were it not for the inconvenience that is felt in ploughing in that direction, these furrows would even operate more efficaciously, in most cases, in drying the ground, than the drains. For, it must be observed, that in making hollow-drains, it becomes necessary that they should not be so far filled with brush-wood, or other porous matter,

through which the water can be permitted to sink easily, as to reach the plough-furrow ; otherwise that matter would be deranged by its operations, and in such stiff mould, the earth that is put above the brush-wood is apt to cake, and become solid, so as to resist the entrance of water into the drain. This is a very serious evil, which every person who has land in that situation, must have often experienced. Open furrows are entirely freed from all danger of this sort. Where dry peat-drofs can be obtained in abundance, for filling the drains at top, this inconvenience would be obviated. See Treatise on Peat Moss.

But, although the facts above stated sufficiently evince, that the loosening the surface mould to a sufficient depth, in a soil of the nature here treated, will, in most cases, prevent the necessity of under-draining of any sort, and in *all* cases will effect a great and radical improvement ; —yet I wish not to be understood to say, that under-draining will not prove, in some cases, useful. But even in those cases where they may prove useful, the number  
of

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of drains wanted, will be prodigiously diminished. If the process above recommended be adopted, one drain will, under these circumstances, do more good than a hundred would do without it—(indeed, no number of drains whatever could so effectually meliorate the soil) and, it deserves to be remarked, that where such a drain shall be made, the evil just stated may be entirely obviated; for as the plough never reaches near to the bottom of the mould, the hollow-drain may be filled quite to the top of the clay, or even above it, with porous matter, without any risk of its being deranged, and it will, of course, keep always open, to receive any water that may have occasion to fall into it.

As to the most advisable mode of deepening the soil, many considerations require to be adverted to, before that can be determined. In general, the surface-mould is more mellow than any of the bottom soil, on which account, it ought not to be buried by trenching it down; the effects of which, upon a very stiff clay, where manures are not extremely abundant,

dant, can very slowly be overcome. In such cases, it will be more adviseable, after having turned over a large and deep furrow of the surface-mould, to make men follow, in the same furrow, with spades, and dig it over, without turning it upon the top; or loosen it to a considerable depth, with an implement which may be called a *crow-spade* (being a small iron crow, sharpened at the point, into the form of a very narrow-pointed spade, not exceeding three inches at the broadest part) having a foot-piece projecting from the stalk, and a cross handle of wood at top, which I have found to be a strong handy tool for works of that kind. Where the soil is perfectly free from stones, a kind of plough, having a share and cutters only, for loosening without turning over the soil, may be made to follow the other plough, in the same furrow, an implement which has been lately introduced into Lancashire, under the name of the *miner*. This kind of under-mould loosening ought to be repeated from time to time, when it is perceived to get bound below; but the surface-mould should always be preserved  
at

at top. In most cases, where circumstances permit of it, the friability, dryness, and productiveness of such a soil will be greatly promoted by a *copious* admixture of lime or other calcareous-matter with it. The *quantity* can scarcely be too great; but on such soils a dressing of a chaldron or two of lime per acre, will be so disproportionately small, as to produce scarcely any sensible effect. In every case, soils of this nature admit of, and in their poor state require, a more abundant manuring than any others. After they have been thus enriched and meliorated by time, they will produce greater crops than any other soil, even with a moderate quantity of manures.

It would be foreign from the scope of this Essay to enter more fully into the proper mode of managing such soils, or of peculiarising with great nicety the diversity of soils that all belong to this general class. These diversities are very great, and some kinds will repay the expence much sooner than others. It is the proper business of the husbandman to distinguish these; it only belongs to me here to say,

say, that *all* of them will be greatly benefitted by the process recommended. Neither must I here stop to explain in greater detail the most economical ways in which the soil may be opened up, I shall only in general add, that deep ploughing, in the ordinary operations of tillage, *at every time it is stirred*, is by no means necessary.—(See farther on this subject, *Essays on Agriculture*, vol. iii. p. 298.)

I cannot omit, however, on this occasion, to take notice of the absurd impolicy of that rule which prevails in most counties in England, of prohibiting grass lands from being ploughed. In all cases of this sort (and many millions of acres of this description of land are found lying in the most unprofitable kind of grass) it is the same thing as dooming the best land to a state of perpetual sterility—for such land, when suffered to lie in its natural state, produces next to nothing in grass; yet by a spirited and judicious mode of culture, continued for a sufficient length of time, it becomes the most productive of all soils. I could easily point out soils of this kind, which, if left to grass, in their natural state, never could have yielded half a crown of  

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rent

rent per acre, that have been brought, in the space of a few years, to yield crops of wheat from seven to nine quarters per acre; a weight of crop that no soil I know, but those of which I now treat, could ever be made to produce.

Were I to call those improvements, *discoveries*, which are merely the result of the exercise of the common powers of reasoning from facts that daily occur; and were I to value such discoveries in proportion to the extent of their utility to mankind, I should perhaps reckon the above one of the most important discoveries that has been made in the art of draining in the present age; because, for *one acre* of land that can be drained by means of tapping, there are perhaps several *thousands of acres* in this island which may be benefitted in a very high degree by this very simple process. Indeed, unless it were for the surprize that the mode of draining on the principle of tapping excites, at first, upon the mind of those who have not adverted to things of this kind, and the quickness of the effect it sometimes produces, at little or no expence, where *it is well understood*, and properly

perly applied, it must hold an inferior rank to many other modes of draining that have been long practised, because of the much smaller *extent* of the evil that can thus be removed than by many of the other modes of draining that are developed in this Treatise. More mischief is often produced by a single spring, in the case I am just about to illustrate, than is experienced in a whole county by that peculiar kind of wetness which *can* be removed by tapping. Of the bogs that are found in this island, perhaps not one-thousandth part of them could be reducible to that class which admits of being cured by tapping. I now proceed to give a few additional illustrations, with a view more clearly to elucidate the principles already explained.

As the whole success of practical draining depends upon accurately discriminating between the cases already stated (though, perhaps, with too much brevity) in the foregoing parts of this Essay, my chief aim in these Additions, shall be, so to mark these cases, as to enable the reader to distinguish them. This he will find no difficulty to do where the case is



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is *simple*; but in compound cases, he may be, on some occasions, a little at a loss. These difficult cases are, however, very rare, and if he be attentive, he will, after a few trials, be easily able to discriminate them also.

Let the reader never lose sight of the fundamental principle, that all springs are produced in consequence of the water which falls from the atmosphere, upon high grounds, sinking through some kind of porous earth, until it comes to a bed of clay or granite, or other matter that is impervious to water, stopping it from sinking farther, and, of course, forcing it either to rise upwards, as in a reservoir, till the cavity be filled, or making it find a passage through subterraneous pervious strata, till it reaches the surface of the earth, where, according to the circumstances of the case, it either issues at once a pure stream of clear water, running forward in rills to the nearest streams, or oozes obscurely forth through innumerable small orifices, into the porous vegetable mould, which produces that wet weeping

weeping appearance, denominated *spouting ground* or *bogs*.

It will be unnecessary here to accumulate particulars, respecting clear springs. In general, where these occur, little more is required by the farmer, than that the channel be so opened up, as to allow that water to flow off in a free current, in the direction that nature points out; in such a way, however, as never to force it, or even to permit it to be absorbed and lost in the soft vegetable mould that may chance to lie in its way on its passage towards the sea.

And here I may be allowed to observe, that those who wish to get a clear idea of the principles of draining, will do well to begin their studies in mountainous or uneven countries, rather than in plains; for, in the first case, they will meet with many facts, that are obvious on a slight inspection, which cannot, without great difficulty, be made apparent in a flat country. It is, perhaps, owing to an inattention to this circumstance, that so few men who have *practised* draining, have understood the principles of their art; which is doubtless  
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the cause of those numerous failures that have been experienced in the *practical* efforts of those, who, in certain cases, have performed cures, that merited the highest degree of applause.

Where a stratum of sand, rock, gravel, or other porous matter, lies in a regular slope towards the earth's surface, supported by a bed of clay (as in Fig. 25) if that stratum has not been deranged by earthquakes, or other violent convulsions of nature, it usually stretches back to a great distance, perhaps at a great depth beneath the surface of the hill, and where it crops out, as at A, if the stratum runs in a horizontal position (which is often the case) when viewed at right-angles to the section here given (which exhibits the natural dip of the strata) it there forms a kind of zone, running along the brow of the hill, nearly in a horizontal direction, for a great way. I have often thus seen a zone of this kind, running along the brow of a hill, nearly at the same height, for miles together; its course being marked everywhere, by a wet uncomfortable stripe, of inconsiderable breadth, frequently broken into small holes, by the feet of cattle, or  
I other

other accidental circumstances. Wherever this indication appears, you may, with next to a moral certainty, conclude, that the evil originates from this source, and you may, therefore, boldly adopt the mode of cure that has been already indicated for this evil; see page 72. A small ditch opened all along the lower part of the spouting zone, that shall be, in every case, so deep as to pass through the pervious mould, and shall penetrate into the bed of clay, or other impervious stratum below, will with certainty intercept the water, and remove the evil, in as far as affects the lower grounds.

Those who have not turned their attention to this subject, will scarcely be able to form an idea of the benefit that may be derived from this simple and easy process. I have frequently seen, in commons, and other neglected places, where the hand of industry has never been exerted (especially in Wales) that a spring of this kind has drenched fields for miles together, rendering the soil one universal cold soft kind of swamp, unfit for producing any kind of vegetable, that is nutritious either for man  
or

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or beast ; for wherever the surface soil is so tender as not to be capable of carrying the water, it sinks through that, and endeavours to force a passage for itself towards the bottom of the hill, along the top of a bed of clay, frequently mixed with stones, that will, in general, be found at no great depth beneath the surface. . And as this water is thus interrupted in its course by the resistance of the quaggy mould, it is alternately seen to rise upwards, running through small pores, till it flows forwards a little on the surface, and then sinks downwards through the soil again. Millions of acres of land have I seen, that have lain in this neglected state for ages, which is unfit for any thing else except that of rotting the few miserable sheep that are suffered to straggle along its surface, and might be drained at an expence that is inconceivably small.

All that is required for draining land in this state, is to cut ditches across the slope, nearly in a horizontal direction, giving them merely so much dip as to allow the water to run off through them freely. These drains must always penetrate, at-least, one foot or more, in proportion to the quan-

tity of intercepted water, into the solid bed, below the soft surface-earth; and this surface-earth seldom exceeds one foot in depth. The earth that is taken out of these ditches, where it is not meant that it should be made to serve as a fence, ought always to be laid upon the *lower* edge of the bank. There, by its weight, it will serve to consolidate the earth on the lower lip of the ditch, which will make it better resist the entrance of the water, in time of floods, when the ditches may be fuller than usual.

No sooner will such a ditch be made, than the water will be seen to trickle into it, from the higher side, through the whole depth of the mould; but it will also be seen to flow most freely immediately above the clay. The lower part of the field, thus deprived of the sources that used to supply a perpetual moisture, will, in a short time, become drier than before; but it will require a considerable length of time to allow the whole water gradually to drain from it. And as the water that is nearest the ditch must pass through the whole of the soft ground  
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below,

below, before it can make its escape; it is evident that if the slope be long, it will require a great while to free the lower parts from wet. To facilitate this operation, other drains of the same sort should be drawn, nearly parallel to the first, at small distances (from one to two hundred yards) below each other. This will not only accelerate the operation, but it will also enable you to intercept, and thus to discover, any concealed springs that may accidentally break forth in any part of these neglected wastes.

I would here mention, that if in driving your ditch, you should accidentally cross a bed of sand that lies deeper than the bottom of the earth, care must be taken to obviate this evil, were it not so apparently necessary as scarcely to deserve being mentioned. The way of obviating this evil will be gathered from the general tenor of this Essay, and need not be here particularly specified.

When a bed of sand, which serves as a receptacle of springs, instead of terminating abruptly on the surface, as at A, Fig. 25, extends to a considerable distance,

in a direction nearly horizontal, as from A to B, Fig. 26, the circumstances will vary. In that case, if the hill from whence it issues, be of considerable extent, whether of great height or otherwise, the water will flow throughout the greatest part of the year with a stream pretty equable; and if the bed of sand be moderately deep, that water will never be forced so far upwards among the sand, as to prove hurtful to vegetation; and it will form a field of a dry sandy soil.

But if some grounds rise above this to a considerable height, which are so formed as to throw the water that runs from them, during violent rains, into places where it can sink freely into the bed of sand, it will then force forward a much larger stream of water towards A, than at other times; and, of course, that water will rise to a greater height among the sand than before (and the same phenomena will occur, if the surface-water, during rains, be brought from a great distance, till it reaches the upper part of the bed of sand, towards B, where it will be absorbed). In that case, the under part of the bed of sand,



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land, towards A, where it is not so deep as above, will become very damp, while that above will remain dry. When this case occurs, the cure is, to dig a ditch across the field, at the place where the wet first begins to show itself during the wettest season, quite through the bed of sand, till it penetrates into the clay (as in every case of this sort) the open part of which must be of such a size as to carry off the whole of the water it intercepts in its course. In these circumstances, however, it will be well to observe, in the first place, whether the bed of sand be not interrupted at its lower end, by a bed of some more impervious matter, which, by preventing the water from flowing off as fast as it comes to it, forces it up towards the surface; for, in that case, it will be, in general, much less expensive to open a ditch through the impervious stratum, that interrupts the stratum of sand in its bed, and running that ditch up the hill, till it comes forward to the sand; and to make it of a sufficient depth, which will give free vent to the water, than to drain the field in any other way.

This is a case that ought to be carefully adverted to; for no soil that I know, is more worthless than a damp sand.

In all the cases above specified, it is very obvious that no sort of benefit could possibly be derived from the practice of tapping.

Nor, unless in the very last-named peculiarity of the case, could drains, if carried in a direction *up the bill*, afford any efficacious remedy, even if they were made at a very small distance from each other; for the water would follow its course down hill between the drains, nearly as before the drains were made.

The doctrine of wells being so intimately connected with that of draining, I shall hold myself excused for making some remarks on that subject, where they are incidentally suggested by the circumstances treated.

Let it be observed, then, that in cases of the sort now under discussion, if the water were supposed to have a free issue at A, were a well sunk into the bed of sand, at B, no water could be there permanently found until it penetrated quite through the  
stratum

stratum of sand, and went to some depth into the bed of clay below it. In this case, the water could never rise in the well much higher than the line *b c*, Fig. 27, because, whenever it rose as high as the porous sand, it would flow along through it, till it made its escape below; and if the bed of clay extended backwards underground a great way, and at a great depth below the surface, so as to form an abundant and never-ceasing stream under the bed of sand at B, it must follow, that the well will continue constantly at the same height, exactly like a stone basin at a fountain, into which a pipe of water constantly flows, so as to keep it running over. This happened to be exactly the case with a well of water that was at my door in the neighbourhood of Leith. A bed of sand reached from the surface, to the depth of twelve feet, nearly; the well had been sunk about three feet in the clay upon which the sand rested, and the stream of water was so abundant as to keep that part of the well which was sunk in the clay constantly full, so that it was scarcely ever known either to sink or to rise

rise six inches above or below its ordinary stream.

But if the stream that runs below the bed of sand be small, and the draught of water from the well, at particular times, be uncommonly large, the surface of the water in the well will of course be made to sink : it may be indeed quite drained of water at times, so as to require to be left for a while till it shall fill again. This may be occasionally a very serious inconvenience, and ought to be guarded against by enlarging the reservoir, which may be effected either by widening the diameter of the well, or by sinking it to a greater depth in the clay, or both. Hence, it appears, that *in cases of this sort*, a very *wide* well ought always to be made. Other cases will come to be noticed in the course of this Work, in which the straitest well that can be made, would supply a quantity of water as abundant as those that are wider.

Nor would the phenomena here described be in the least varied if the well, instead of being dug in the sand immediately below the vegetable mould, as at

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B, should be first sunk through a considerable thickness of some other strata, as at C. The depth of the well only would be greater, and all other circumstances the same.

Please also observe, that if there be an opening at A, so as to allow the water to issue freely from the surface of the bed of clay, the body of sand above it will be a firm solid body ; and in this case, if houses are founded upon that sand, with the precaution of putting planks of wood, or large flat stones, as a foundation for the walls, these buildings will remain as stable for ages, as if they had been founded on a rock. This is precisely the case with the town of Leith, the sea-port of Edinburgh, the houses of which all stand upon a bed of sand from eight to twelve feet deep ; and there are houses there of more than a hundred years old, the walls of which are now standing as true to the plumb, as if they had been built but yesterday. But if, instead of having had a free issue at A, the bed of sand had been there interrupted as at A, Fig. 21, the water, in this case, would have been regorged  
back

back among the sands, and, perhaps, would have formed a bed of that unmanageable body, which architects so much and so deservedly dread, under the name of *quick-sands* \* ; and which, when it comes in the way in digging wells, or other subterranean operations, presents obstructions that can be only with great difficulty surmounted.

The obvious cure of this disease (quick-sands) when it occurs, is to search for the means of opening an outlet by which the water may be suffered to run off,—This,

\* An apology may, by some, be judged necessary, for here incidentally mentioning *quick-sands*, as a thing that may, perhaps, be thought in some measure foreign to the subject. As I aim at giving clear and discriminative ideas on every case that may occur in the practice of draining, and as this case may, and certainly does, sometimes occur; it does not seem to be foreign from the object of this disquisition: and it appears to be the more necessary at present, as I do not know that any satisfactory explanation has ever yet been given to the public, of the circumstances which give rise to the phenomena of quick-sands; and of course, no rational method of removing this distressful malady has ever yet been attempted. A very able engineer, some years ago, from a total inability of forming clear ideas on this head, made some very ridiculous estimates of improvements proposed at Leith; which he never could have done had he been better informed on this head.

where

where the quicksand is situated above the level of the sea, or some adjoining plain, may in many cases be effected at very little expence; if due attention be bestowed upon the position and natural dip of the strata, which may be discovered by various means besides boring.

But there are cases, particularly where the quicksand is produced by a cavity like a basin scooped out of the entire bottom, so as to contain water to a considerable depth, which in some particular situations may be deemed incurable.

It deserves also to be remarked, as a circumstance necessarily accompanying springs of this kind, that the digging wells in a higher position, as at C or B, will not sensibly diminish the quantity of water that flows over the lower surface of the clay towards A; for, as the well, as soon as it is filled, must overflow; that will intercept not one drop more water than what is drawn up out of it. Were it even possible to pump the water from the well, as fast as it falls into it, so as never to allow one drop to run over, the case would not be much altered; because no more water could be  
thus

thus intercepted than that which would have flowed into the mouth of the well in its descent, so that every drop that would pass the mouth of the well, on either side, would flow forward to the lower situation, as if no well had ever been made. Hence we see that springs of this sort can never be intercepted by wells, or sensibly affected by other wells placed either higher or lower than them. Wherever this case exists, water will be found nearly in equal abundance, whatever the relative situation of the well may be in respect to others; nothing but an *uninterrupted trench*, of a size sufficient to intercept *all* the water as it flowed, and to carry it off, could dry up the springs below it.

: We may also observe that if the bed of sand be of great extent, if it be at last supported by a bed of clay or other impervious matter, water will undoubtedly be there found, whatever may be the depth of the bed of sand above it, if a well be dug through it; for, as the water that falls in showers upon the earth's surface necessarily sinks through that pervious stratum, it is soon beyond the reach of the sun, so as not  
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to be evaporated, and must sink downwards till it meets with an impervious stratum, so that there can be no doubt but that under the immeasurable deserts of Lybia, there must be water in abundance, to supply any number of persons, were wells there sunk to the requisite depth: Nor is that depth perhaps, in many cases, nearly so great as has been in general apprehended.

I may here also be permitted to observe, that many instances occur of streams of water flowing over the surface of beds of sand of the kind here described, without sinking into these sands. Sometimes the surface-sand is even rendered hurtfully wet by water stagnating upon it, while springs of the sort above described, are freely running below. This phenomenon is occasioned by a natural process, similar to that which is now adopted for rendering canals retentive, called *puddling*. When this happens to be the case, the stagnating surface-water may be let off merely by digging a hole till it penetrates the crust which has been rendered retentive by means of the natural *puddling* process, and till it reaches the unmixed sand, through which it will  
sink

sink with the greatest facility. I have often, in this manner, opened up a hole, in the space of half a minute, in such situations, which has swallowed up at once a stream that flowed into it, which was so abundant, that, with a moderate fall, it might have turned a mill; and which if not thus let off, might have produced very extensive mischief, by flowing over the surface of the ground. In such cases, the small opening thus made, in a short while, becomes *puddled* so as to be retentive, and thus closes up, so that a fresh hole must be opened, if the stream continues long to flow, where much mud is carried with it.

Let us again suppose that A B (Fig. 27) represents a stratum of sand, gravel, stone, or other pervious matter, lying between two beds of clay, E F and C D, which unite at the point A, where the stratum of sand is interrupted. In that case, the water which flows from B towards A, when it reaches that point, will be pent in, as if in a horn, so as to have all the vacuities filled with water till it rises to B, or some other point where it can be permitted to flow off. If the upper bed of clay, E F, be of a sufficient

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cient thickness and tenacity to resist the whole pressure of the water below, the surface soil will be in no manner incumbered by it; but if that bed of clay be not very thick, the water will be squeezed upwards through any small cracks that may occur, producing spouting-ground or bogs on the surface, as described in the First Part of this Essay. In a case of this sort, it is very plain, that no surface-drains could afford any adequate relief—for while the water is suffered to remain in the reservoir below, no operation performed upon the surface can prevent the water from being pushed upwards, through the natural channels it will find for itself. In this case, tapping is the only remedy, which, by giving free issue to the water through an opening made for that purpose, in the upper bed of clay, diminishes the altitude of the confined water within, and, of course, removes the pressure from below; which, as it was the sole cause of the malady, a radical cure must thus be effected.—The only question, then, that now requires to be decided, is, “in what manner ought we to

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proceed,

proceed, so as to effect a cure, *at the least expence possible to the employer?*”

Let us suppose that the whole surface between G and L is hurt by superfluous water—but that towards L, the ground becomes gradually foundered, the surface near L being only wet during rainy weather. In this case, should a ditch be drawn along the face of the hill at L, in a direction nearly horizontal, allowing only a sufficient declivity to carry off the water in it, it is plain that this ditch, unless carried to a very great depth, at an enormous expence, could do little or no service.—And if it were here tapped, by boring a hole through the bed of clay, as is represented by the line at L, the relief it would afford would be very inconsiderable; as it could, at the utmost, give vent to the water only until it sunk to the level L K, so that all the parts of the field below L would be little better than before.

Should another ditch be opened in the same manner, lower down the declivity, as at M, and should it be there also tapped, the water would then be allowed to subside  
to

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to the level-line M N ; and all the ground between L and M would be effectually drained. In this case, we have derived some benefit from our operations, though at an expence greatly more than was necessary; for if the operations at M had been first made, the drain would have been as complete as it now is, though nothing had been done above — All that has been expended on the operations at L, then, would be money thrown away to no purpose whatever.

Still, however, the ground between M and G is in want of draining, and we must now go lower down : Suppose we should go at once to G, and there make a similar ditch and tapping ; in that case, the water would be made to sink to the level G H, and the whole field effectually drained at once. It is scarcely necessary for me now to remark, that had this been done at the first, the field would have been as effectually drained, without any of the operations above. I state these particulars, here, by way of illustration, as a caveat which ought not to be neglected—for I have often observed, that men who attempt to drain land, without understanding the principles of the

art, have a great propensity to follow the mode of conducting their operations above described, who, if not restrained, may, in many cases, subject their employers to a most exorbitant and unnecessary expence, even where they do at last succeed in the purpose intended.

Observe, however, that in this particular case, had the tapping been made lower down, as at I, no good whatever could have been derived from the operation at that place: As this case but rarely occurs, yet from this illustration the use of the previous boring for exploratory purposes is made very manifest.

It has been shown in the First Part of this Essay, in what cases a ditch opened upon the *upper* edge of the wet ground is required for effecting a complete drainage—to which the reader is referred.

The surest rule, I can at present think of, for distinguishing the cases, where this mode of proceeding (that is, by means of a ditch carried across the declivity, above the highest part of the wet ground) will be useful, from those in which it must prove nugatory, is this: Wherever the water that is to be carried off, can be made to find access  
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into

into the ditch only by means of *tapping*, there the opening of a deep ditch, in this situation, may be declared nugatory—and wherever a ditch in that situation can prove radically useful in draining the lower grounds, there tapping can prove of little or no service whatever.

Another economical consideration, that ought never to be lost sight of, is, that in the mode of draining by means of tapping, ditches of a *great depth* can never be required, so that if deep ditches are ever made where this mode of draining is adopted, it must be accounted a mere *useless expenditure of money*. The only use of the drain, where tapping is beneficial, is not to *intercept*, but merely to *carry off* the water.—And if the drain be of a size just sufficient to carry off all the water that rises through tap-holes, nothing more can be required. In general, a ditch of two feet deep will effect this purpose as well as if it were twenty—but the expence of making it will be very different.—As there are men, however, who value things merely in proportion to the money these things cost them—it deserves the consideration of *practical* drainers,

whether it would be *prudent* in them, to lay aside expensive and stupendous operations, which often strike the imagination of men, and thus make the improvements which seem to require this expensive apparatus be attended to, when trifling operations, though equally efficacious, would be neglected and despised? Let Noblemen, and others of high rank, then, be indulged in these expensive and showy operations—the country is benefitted by them—But if ever practical farmers should engage in undertakings of this sort, it is proper they should advert to the article expence, as of the first importance.

In all cases of this sort, now under consideration, where the current of water that flows in the pervious stratum is not very great, and where that stratum continues without interruption, and undiminished in size to the bottom, the drainage will be completely effected, by tapping in the *lowest* part of the field only.—But where the depth of the pervious stratum is diminished considerably, as at A (Fig. 28) or, what comes to the same thing, where it meets with casual though not total interruptions—  
and



and if the current of water should be considerable, it may happen that a small part of the water only (viz. less than flows into this reservoir from above) can reach the point A, and as no more water than reaches that point can be made to rise through the holes there made, it must in this case happen, that the drainage will not be completely effected by the opening at A. In that case, after trial has been made, and time allowed to see whether the drainage is complete or not—should it then be found necessary, it will be proper to go higher up, as to E, and there open some fresh taps; and should that be still found inadequate for the purpose intended, go still higher, to D, and so on, higher and higher, till it be finished.

In cases of this sort (which are rare) it will be proper always to *begin* at the lower extremity—and if water rises at all where tapped, be sure to make the tappings sufficiently numerous to allow the whole of the water that comes to the place where they are made to issue freely. You will easily know when these openings are sufficient for the purpose—for, in that case, after a

short while, the water will not rush up through them with great violence, but will flow off gently, without any appearance of boiling up.—If that appearance of boiling does not subside, it is a sure indication that a greater number of tap-holes are wanted—and they ought to be made. If this be first done, and you find that even in the wettest season, the water rises gently through the tap-holes, you may then, in general, be satisfied that no opening above will be wanted; but in order that no doubt may remain on this head, you may easily satisfy yourself, at a very small expence, whether any openings above are wanted, merely by putting down a bore by your tapping implement, at some little distance above the former opening. If the water, in that case, rises in the tap-hole you have just made, it is a sure indication that openings at that place are wanted; and, therefore, a drain should be there opened, and taps sunk in it, as before—but if during the rainy season no water rises through the tap-hole, it is an indication equally clear that no openings are there wanted. In this manner, by boring only, without making drains, until  
you

you see whether they are necessary or not; you may proceed upwards, till you ascertain the facts with precision.—By means of the boring instrument, also, you may ascertain with precision the nature of the strata, and their limits, where they are broken or interrupted, so as to be able to know with certainty, before you commence your operations of expence, in what manner you ought to proceed. General ideas, collected from external appearances, may serve very well to direct in plain cases, or to indicate where anomalous cases occur; but in difficult cases, particularly where the strata are broken and jumbled together, external indications can only produce guesswork. The borer only can be relied on.

It will not be expected that I should here enter upon an enumeration of anomalous cases; for these may be so much varied, as that a complete volume could give but a partial statement of them. Fortunately, cases of this sort are few, and of comparatively small extent. There are particular cases where the strata have been much deranged, more especially where rocks intervene, in which the expence of draining

draining would be much more than could be repaid by the subject. But these bear such a small proportion to the fields that could be drained with profit, as scarcely to deserve to be named in a treatise which relates to practical cases alone.

I have already mentioned some cases that relate to digging for wells. The following cases are of a different class :

Probably, some of my readers may recollect having read in the Philosophical Transactions, some years ago, an account of the phenomena that occurred in sinking a well at Sheerness, near the mouth of the river Thames ; some of which phenomena were deemed, by many persons, rather of a wonderful kind. They were as follows : That fort is placed upon a neck of land, very little elevated above the surface of the sea. In digging the well, they passed through a bed of solid clay, to the depth of. . . fathoms, without finding water of any kind ; but at that depth, they found a spring of *salt* water ; which, not being irresistibly abundant, they found themselves enabled to wall it out. This being done, they then sunk, once more, through

through the same bed of clay, for fathoms more. Here they found another spring of *salt* water, as before ; which, having walled out also, they continued to dig through the same bed of clay, for 300 feet more ; at the bottom of which they found a bed of gravel, from which issued a copious stream of fresh water, which soon filled the well within five feet of the top, at which height nearly it has remained ever since.

Wonderful as this may seem, at first sight, to some persons ; it will appear, in no respect, inexplicable to those who have adverted to the phenomena that occur in the tapping for springs, so fully explained in the foregoing parts of this Essay. Let A, Fig. 29, represent the fort ; B the sea ; CDE a bed of solid clay, stretching out beneath the sea, and backward into the land to an indefinite distance. FGH represents a stratum of gravel, or other pervious matter, lying upon another bed of clay, IKL. Under these circumstances, the stratum FGH, having no opening at the lower end, must form a reservoir of water, which must rise upwards towards F, till

F, till it finds some opening near the surface of the ground, through which it can make its escape. This being the state of things, it is very obvious, that as soon as the well MN reaches the bed of gravel N, the water contained there must be forced to ascend till it reaches as high as the water contained in the internal reservoir within the mountain. If the spring affords more water than is taken from the well, it will continue always at that height; so that the water can only sink in the top of the well, when more is drawn from it than the spring can supply in a given time.

With regard to the salt-water springs, the diagram will explain that phenomenon, at first sight. At P and Q, two fissures, occasioned, perhaps, by the working of some animal, or other unknown cause, have penetrated the bed of clay, from the edge next the sea, to some distance as far inward, at least, as the pipe of the well, through which, of course, salt-water would flow, into the well as soon as they were opened.

Another phenomenon of a similar kind,  
but

Fig. 25

Fig. 26

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Fig. 28







but less complicated, because divested of the circumstance of the salt-water, is mentioned by Dr. Darwin, of Derby : A well was sunk in that town (which lies in a bottom, surrounded with many hills). After digging through a bed of clay for some considerable depth, they found an abundant spring of fresh water, which, as in most cases of this sort, rushed up with great impetuosity, and soon filled the well to the top, where it flowed over in a pretty copious stream. Dr. Darwin seeing this, and conceiving that it might descend through a subterraneous funnel, that rose to a greater height than the houses of the town, easily perceived, that if he could raise the sides of the well to a sufficient height, making them, at the same time, strong enough to bear the pressure of the water, he might get it thus conveyed to the highest floors of his house. This he actually effected, and enjoys, I suppose, the benefit of his ingenuity, till the present moment.

I do not hear that Dr. Darwin has thought of extending this discovery to any other use ; but if an abundant spring  
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should be thus discovered, which could be forced, without the power of machinery, to rise to a great height, it might, doubtless, in a mountainous country, where phenomena of this sort must chiefly occur, be employed to great advantage as a power for turning machinery. To illustrate this subject, let Fig. 30 represent the section of a hill, containing an internal stratum of pervious matter, inclosed between two solid beds of clay; in other words, an internal reservoir, filled with water. If this reservoir should be discovered, by means of boring, or otherwise, as at AB, and it was found that the water would rise to the height of A; then, by digging a shaft, of sufficient dimensions, and building the sides of it as you proceed, till it reaches the gravel at A, then the water would rise and flow over at A, till the internal surface of the water sunk to the level of the line AC; after which, the whole water that the spring supplies would continue to flow over at A, and form a perennial stream, perhaps extremely abundant; the uses of which, in such a situation, are very obvious.

vious. St. Winnifred's spring, near Holywell, Flintshire, which is so abundant as to turn nine mills, is a natural burst of the same sort with that I now describe (for it is not a great while since it first appeared). But were the spring much smaller than it is, the great height of fall that might thus be obtained, would give it a commanding power for turning machinery.

Should an opening of the kind here mentioned be ever made, it is plain that its effects must be sensibly felt in some other place; exceedingly so, indeed, if the stream be abundant; for a reservoir of the kind here supposed, must, of necessity, have an outlet somewhere, for discharging its waters; and, as in the case here supposed, that outlet must be on a higher level than the other, it could not fail that when this last was opened up, the other must have failed, so that a stream which issued perhaps from an opposite side of the hill, possibly, at many miles distance, would be entirely dried up, and another formed, that might take a direction to the sea totally different. These phenomena, when thus explained, are as natural as that the sun

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should

should give light when it shines ; and can excite wonder in the mind of those only, who have never adverted to the physical conformation of our globe. Indeed, the *borer* has been but too little used, in consequence of which, many facts that might have been highly beneficial to man, have totally escaped his notice. I shall beg leave to specify a few, with a view to direct the attention of the public to this interesting subject :

At Halle, in Germany, a spring of salt-water was discovered, many years ago, which when manufactured into salt, affords a great revenue to the King of Prussia, in whose dominions it is placed. Halle being situated very near to the confines of Saxony, the Elector was in the practice of purchasing brine from thence, which he carried into his own dominions, and there converted it into salt, for the use of his subjects. As the carriage of this brine was attended with a considerable expence, the Elector often expressed an earnest wish, that a spring of salt-water could be found in his own dominions. This turned the attention of his people to this subject,

ject, and at last an unlettered peasant, in the neighbourhood of Leipfig, presented himself at court, and made offer, at the risk of his head, to find salt-water at a place he should indicate, if the Elector would be at the expence of digging for it. —It was some time before this poor man could adduce such arguments as to satisfy the Electoral council, that there was such a probability of success, as to authorize them to risk the experiment ; but at length he prevailed. The work was begun at a place called Durlinberg about 15 miles distant from Halle. For some time nothing extraordinary appeared, but at length they came to a spring—of fresh-water only.—This did not discourage the peasant, who ordered them still to go on. With some difficulty he effected this point; but as the water from that spring incommoded them a good deal, it excited a murmur against the poor man. After digging somewhat farther, they came to a second fresh-water spring, which threw the undertakers into such a rage, that they would not listen to the poor man, who urged him still to proceed ; but, on the contrary,

the man seeing them in such bad humour at being frustrated, after having expended so much money, he began to dread some mischief to himself, and secretly withdrew himself from the electoral dominions. Soon after this event, the king of Prussia overran Saxony, during the seven years' war, and the operations at this well were forgotten. When peace was afterwards restored, and the minds of men a little cooled, the peasant ventured to return.—His mind was still set upon completing his enterprize; and he spoke with so much firmness on the head, and adduced such cogent arguments in favour of his opinion, as prevailed upon the court a second time to begin the work; he having the precaution before they began to tell them, that as the spring was probably at a considerable depth beyond what they had as yet reached, they must be determined not to be soon discouraged. They again went on, and, as he had said, they did indeed, when at a very considerable depth, open up a spring of *salt-water*; which rushed into the well with such impetuosity, as soon filled it to the top, over which it flowed,

flowed, for some time, in such abundance, as to occasion considerable damage ; but this violent burst subsiding by degrees, they began to erect salt-works, which continue to be worked till this day. This is one practical proof, at least, of the benefit that society may derive from the study I here wish to recommend. Nor have I a doubt, but if it shall be properly attended to, many other benefits, equal to the above, may be derived from it.

It is well known, that at Newcastle upon Tyne, and at Bo-ness, in Scotland, coals are dug at a great depth below the level of the sea ; and even below the bottom, and immediately underneath it.—As no salt-water is discovered in these coal-mines, it affords the most demonstrative evidence, that the bed of clay that lies above the coal is perfectly impervious by water ; of course, the water which is found in the coal-mines, and which occasions much expence to discharge it, can get access into it in no other way than by descending along the tract of the coal-seam, from the place where it approaches towards the surface of the

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ground,

ground, exactly in the same manner that springs are accumulated in other pervious strata. Hence it must happen, that if this stream of water should be intercepted in its course, and there carried off to the surface of the ground, no water could get into the mine; so that all the coals below that intersection would be laid quite dry, by a process in every respect analogous to that of intercepting the springs, described in page 72, and with an effect *nearly* equally beneficial. I say *nearly* in this case, because no operation of this sort could *entirely* remove the water from the coal-mine; for as there must be some fissures among the coals, through which the water has originally flowed, so these fissures, in a situation like that described, must be entirely filled with water, which would of course run in the pit, after the coals are taken out, but this would be such a trifling matter, as not to deserve any notice.

Let A B (Fig. 31) represent a seam of coals, rising at A towards the surface, and at B dipping beneath the sea. Let it be supposed, that at C it has attained such an elevation



elevation as to be above the level of some vale or rill of water, and that, of course, a level driven from the surface at that height, till it reached the coal, might serve the purpose of carrying off all the water that should fall into it. In that case, were the stratum of coal there pierced through, as at C, supposing that to be the only stratum permeable by water, it would follow, that all the water which had formerly been conveyed through that stratum, would be there intercepted, and carried clear off to the surface of the ground ; and that, of course, all the coal that lies below it, would be, from that moment, freed from any additional accession of water. In this case, the level would not only serve to free the *upper* part of the coal-mine from hurtful water, which is all the benefit that has hitherto been aimed at in works of this nature ; but the *under* part of the mine would be also benefitted by it nearly to an equal degree.

Where the strata were so disposed, as by varying the direction of the drain, it could be pushed forward, without falling below the level, till it had cut through

the bed of coal for its *whole breadth*, the cure would be quite complete. This case may probably sometimes occur ; but I am as yet too little acquainted with the actual circumstances of this nature, that occur in practice, to be able to say whether it would be very rare, or the reverse. Indeed, as the subject has never been as yet considered under this point of view, I think there is reason to suspect it is not known by any human being. It is certain, that much benefit is yet to be derived from a more thorough investigation of this intricate, though very interesting subject ; and every hint that tends to elucidate it in any degree, deserves to be attended to.

It would be impossible to enumerate all the benefits that might be derived from the practice of *tapping*, judiciously applied, were the nature of the strata, and the physical conformation of the earth, sufficiently adverted to.—Were I even to attempt to give examples of *possible* cases, by way of illustration, it would be deemed hypothetical and absurd. Yet it must certainly be deemed more absurd, by every rational person,

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person, to observe, that we allow natural phenomena, which ought to suggest practical lessons of wisdom to the attentive observer, to afford only matter of stupid admiration. We see, in some places, rivers sinking into gulfs in the earth, and disappearing. In other places, we see subterraneous rivers issuing from caverns, while other rivers are meandering on the earth's surface above them.—We see lakes of great extent, surrounded by mountains, that cannot be drained, according to the ordinary mode of procedure.—Mines are deserted because the water cannot be carried off from them, on account of the immense length of a *level*, that would be required to be driven in order to drain them. All these things we see as isolated facts, that cannot be in any way accounted for, or connected together. Yet that they may, on some occasions, be *so* connected, as to prove highly beneficial to man, I shall venture to show, even at the risk of being accounted visionary.

We have seen, from the fact respecting the well at Tilbury Fort, and the working of coals under the sea, at Newcastle  
and

and Bo-nefs, that water may be preserved in a bafon of immense extent, though bounded by a cruft of impervious matter, which is of no great depth. Thefe cafes alfo prove, that ftrata of pervious matter may lie under thefe ; of courfe, many oozing fstreams, or even fubterraneous rivers, may run, at no great depth, beneath lakes, or rich mines that are drowned in water ; precifely in the fame way that we have feen (page 64) that a fream of water may be carried along the furface of a bed of fand, at the bottom of which runs a current of water fufficient to fupply innumerable wells abundantly with water ; and that this furface-water, if the cruft be once broken, immediately finks into the fand, and totally difappears. Should any accidental convulfion of nature then break the cruft that fupports the lake, fo as to permit it to find its way into thofe cavities below it, it would, through thefe iffues, find accefs to the fea, and the lake would be effectually drained ; fo as to become, in time, like the kingdom of Cachemire, a fertile vale, though every where furrounded with hills, through which no outlet could be had,

had.—Might not the same effect be produced by the ingenuity of man, were he at pains to exert his faculties in cases of this sort? An earthquake, it is supposed, opened a passage through the mountains of Cachemire, by which the water issued, so as to drain that immense lake, and through which the river which traverses that bottom still flows. An enterprising individual, who possessed a small lake on his property, near Glasgow, effected a drainage, in imitation of this, by digging a level passage through a surrounding hill, through which the water flowed off, and which still operates as a drain. Many cases may occur, in which a similar drainage might be effected, at a much smaller expence, by sinking a pit downwards, through which the water might issue by subterraneous passages; and in the same way, at times, it may doubtless happen, that water might be let off from mines at a very small expence, compared with that which the driving a level might have cost. Wherever operations of this sort are in contemplation, therefore, it behoves the owners to advert to these peculiarities, and

and to be at more pains to acquire an accurate knowledge of the subjacent strata, in hilly districts especially, by means of accurate observations, assisted by boring, than has hitherto been done. For in this way, doubtless, very great improvements may be made at a trifling expence.

With a view to illustrate this branch of the subject still more clearly, I have added a diagram (Fig. 32) which is intended to represent a section of a hilly district, in which A B represents a lake of indefinite magnitude, every where surrounded with hills, which raises the water to its present level, where it finds an outlet at A, and flows from thence in a valley between the hills, till after running thus many miles, if you please, it precipitates itself over the rock C.

At the bottom of this hill, C, issues a considerable stream of water from a large cavern, like one of the same kind near Matlock, in Derbyshire. This subterraneous river, we may suppose, indeed, we may be assured, flows from a great distance backward. If it be of a large size, it must have come many miles, indeed,

flowing all the time through open rocks, or other pervious strata, in a direction nearly similar to that marked DE, which may be expected, in general, to lie at a depth rather above than below the level of the opening from whence it issues. Under these circumstances, it is plain, that if an opening were made in the bottom of the lake, as at G, the water would sink directly from the lake, into the channel of the subterranean river, and if that opening were large enough, the whole water of the lake would sink through it, and it must, of course, be effectually drained.

Again, let us suppose that F represents a mine of lead, or other metal, which has been there discovered, but which is so drowned in water that it cannot be worked with profit. According to the usual practice, the owner of that mine has no other way of draining off this water, but by taking the depth of the bottom of the mine, and surveying the ground around it, so as to be able to mark the nearest place on the hill side that is on a level with the bottom of his mine, and from thence he derives a level C F till he reaches the mine. In many situations,

situations, that level may require to be driven several miles in length, before it can reach the mine, the expence of which can never be repaid, and therefore the mine must be abandoned for éver.—And where it is even found that the mine is so rich as to afford the expence—yet the time that must be expended on this operation (where one or two men only can be permitted to work at once) is a most discouraging circumstance, as five, ten, or even twenty years may be expended before it can be completed.—But, in the situation here described, it is evident from inspection, that if a perforation had been made right downwards, from F, it would soon have reached the subterranean river, and thus have freed the mine from the extraneous water, at an expence inconceivably small.

Not only could the hurtful water be thus easily abstracted, but other uses could be made of this subterranean drain, that would prove highly beneficial to the undertaker.—If a small stream of water, for example, could be brought to the mouth of the pit, it could be employed, by means of a chain and buckets, to raise up the whole of the ore to the surface, at next to no expence to the undertakers ;



undertakers ; or, after space sufficient for that purpose was once worked out, it could be made to drive stampers below, for stamping and washing the ore, there, before it be brought out of the mine, and for other uses.

Nor let it be thought that these are chimerical or impracticable notions : There are many situations, already known, upon the earth's surface, where these operations might be undertaken not with a *probability* only, but with a *certainty* of success. The river Guadiana, in Spain, sinks at one place into the earth, and after running under ground for several leagues, rises again to the surface.

—Now as no holes have ever been discovered in the bowels of the earth, resembling a bored pipe, or mole-rut—but the openings there, through which water flows, are universally found to consist of porous strata, which spread out in breadth to a great extent—there is a moral certainty that there must lie beneath the surface of the ground, every where between the place where the river sinks, and where it rises, a large stratum of pervious matter, which probably stretches to a great extent on either side,  
and

and that, of course, if any mines were discovered in that tract, they could, with *certainty*, be drained in the manner here proposed.

It is also known, that in the hill called Ingleborough, in Yorkshire, there are many openings, called there *Swallows*, into which rivulets precipitate themselves, and are lost. Where these streams re-appear, I do not at present know; but wherever it is, there can be no doubt that all the tract between the one place and the other must be hollow, and of course, could readily admit of the mode of draining here proposed.

It is also known, that in Derbyshire, the river Dove, I think (I quote from memory) sinks into the earth, and at a considerable distance rises again.—Subterraneous rivers are known to issue, also, at other parts in Derbyshire, and in Devonshire, in Denbeighshire, and several other places, I have not taken notice of; all of which give sufficient indications of a similar general organization, to render it next to certain, that in those regions, operations of the sort here recommended, would prove successful. The same conclusion may, in general, be  
inferred

inferred in all the mountainous regions, where very copious springs burst forth, whose waters are little affected by the temperature of the season, being very cold in summer, and warm in winter; for this circumstance always indicates, that they have come from a considerable distance within the bowels of the earth—Other indicative circumstances might be pointed out, which I have not time to enumerate.

Having now, as I hope, *proved* in a satisfactory manner, that the mode of draining here recommended is a very practicable process, I shall add nothing farther to the length of this Essay, than to give a few hints respecting the manner in which that operation may be the most easily effected.

On this head, it will be very obvious, that where much water is in the place to be drained, it would be, in all cases, a difficult matter, in many cases impossible, to sink a pit directly downwards, immediately from these reservoirs, by digging. In such situations, this operation ought to be effected by *boring*. When, by means of a borer, the subterraneous vacuum has been

once attained, a certain judgment can be formed of the expence of the future operations. The width of a bore that can thus be made is, indeed, but small; but much water will be let off through a very small bore, under the circumstances here indicated, because of the altitude from which it must descend. If the stratum through which the bore passes, shall chance to be clay its whole length, the hole would quickly become of a sufficient width to give passage to the whole water. But if it consist of harder materials, more bores must be made; and these, if made in a circle, of no great diameter, pretty near to each other, would give the water a chance, by its great force in rushing through, to break down, by degrees, the whole of the circular solid, and leave a cavity in its stead; at any rate, there are few mines which have so much water as could not be let off by a few such bores alone.

With regard to the drainage of lakes; if these are of great extent, it will become a matter of greater difficulty and expence;

pence ; but as the profit will be great, in proportion to the extent, that circumstance will, no doubt, be taken into the account. In all cases, the ascertaining whether the thing be practicable or not, can be done at a trifling charge ; for a single exploratory bore will ascertain not only the depth to which it must be carried, before it reaches the pervious stratum, but also the nature of the materials through which it has to pass ; and, consequently will give room for a pretty accurate estimate to be made of the expence.

In making this exploratory bore, one circumstance must be particularly adverted to ; for as it will be necessary to make that bore, if possible, in the deepest part of the lake, it will be a matter of some difficulty to ascertain whether the small bore, under these circumstances, allows water to flow through it or not ? This point, however, may be ascertained by means of the boring irons alone ; for if the mouth-piece be thicker than the rod, it will no sooner reach the pervious stratum below, than the water, rushing downward with great impetuosity around the

rod, will prevent the possibility of drawing up the mouth-piece any more. To guard against this circumstance, which is to be expected, the mouth-piece ought to be so fixed on, as that by turning the rods the reverse way, it may be unscrewed, so as to be detached from the rods entirely, which may then be drawn up without it. Of course, all the joinings of the rods must be so fixed, as not to be loosened by that reversed motion.

It will not, however, be expected, that where a large river passes through a lake, like the Rhone through the Lake of Geneva, or the Rhine through that of Constance; or even much smaller streams than either of these, could, by a process of the kind here hinted at, be ever swallowed up. There are few subterraneous strata, we are to suppose, so large as to admit of carrying off a current of such magnitude. But if that should be found to be the case, the passage for the river into that subterraneous stratum should be made, not in the bottom of the lake, by boring, but at the edge of it, near where the river falls into the lake; and this passage may be dug,

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dug, by hand, of a sufficient width to swallow up the river when flooded, and then the river may be led into it, so as never to be allowed to reach the lake at all. But this, for the reason assigned, can seldom be practicable with respect to large rivers; and in regard to smaller rills, that feed lakes, in general, it will be cheaper (unless where the under-stratum is clay, and of very little depth) in most situations, to make a water-course all round the lake, nearly in a horizontal position (with a gentle slope only towards the outlet) to intercept all the rills, and the water that falls from higher ground, and carry it clear off, without allowing it to descend into the bottom. In this way, no other water will require to be let off through the bottom hole, than that which arises from springs within the lake itself, which probably are, in many cases, not numerous.

It is to be hoped the candid reader will receive these hints with indulgence, they being intended to throw some light upon a subject of great national importance, which, if it be understood by any one, has

never hitherto been explained with the precision which is necessary to render it intelligible to ordinary readers, for whose use these directions have been made out. On a subject of this nature, I have found, by experience, that it is by no means enough briefly to explain the principles on which a successful practice may be rationally grounded; for it is only a few persons from among the great numbers who may be benefitted by it; who will be able or willing to make the practical deductions that a philosophical mind would see are obvious from the premises. To render a practical treatise generally useful, it is necessary to enter upon particulars in detail, and give special illustrations which philosophical hypercriticism might pronounce to be unnecessary. In the Additions now made, perhaps, little can be said to be new; yet I am inclined to hope, that in consequence of these additional illustrations, the Treatise will be rendered more generally useful than it hitherto has been. I shall only add, that the latter part of these illustrations, especially, were written under circumstances rather unfavourable

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## AND SWAMPY GROUNDS. 167

able for precision, and therefore claim a share of indulgence from the critic, particularly in what regards their form. As to the matter, no indulgence is requested; for if any thing essential be erroneous, it is of importance that it should be corrected.

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### CORRECTIONS AND ADDITIONS.

WHEN the above was written, I had no opportunity of consulting the Philosophical Transactions, and was therefore obliged to quote from memory, the fact respecting the well at Sheerness; and the plate was engraved on the idea there expressed. I have since seen the 74th volume of the Transactions, in which, that fact is recorded, and find it only differs from the account given above in one particular, viz. that the uppermost stratum, to the depth of 30 feet, consisted wholly of sand, and that all the water which was found in that part, was salt to the taste; in every other respect, it was exactly as above stated. This circumstance requires no

alteration to be made, as the illustration would be the same. In a few particulars, of no moment, the case respecting Dr. Darwin's well, is also a little different; but, as this illustration is perfectly the same, it is not worth mentioning farther.

A case a good deal different from this, occurred at Languard Fort, which is also situated by the side of the sea. In digging there for a well through a bed of sand, they found abundance of water; but, as this was below *high-water* mark, they considered it to be salt water, and it was owing to an accident alone, that they found it to be perfectly sweet. They continued to dig down, always finding abundance of sweet water, until, at the depth of twelve feet, they found it suddenly to become more abundant, and perfectly salt. On examination, it was discovered that the salt-water was found exactly at the height of *low-water*; and that all above low-water mark, afforded sweet water only. This phenomenon was evidently owing to the salt-water having had time to penetrate backwards to a great distance, where the sand was below the level at which the  
sea

sea flood continually; but, between high and low water mark, the fresh water in its passage towards the sea, though stopped for a time by the salt tide, yet still pressed forward, and retarded its passage back through the sand: Nor is it to be doubted, that, if free access had been given to the water into the well, while the sand was kept back, that the water in this well would have risen higher at flood, than at the ebb tide.

But, not to dwell on this unimportant circumstance, the practical inferences that may be drawn from these two cases, are important. In the case of Sheerness, no enemy from without could ever entertain the most distant hope of intercepting the water from the fort. The thing is seemingly impossible. In the other case, the water could be cut off by a besieging army without much difficulty, if the country should happen to be pretty level; for they would have only to draw a trench between the high land behind and the fort, till it reached either the bottom of the pervious stratum, or attained the level of *low* water, and

and the business must be effectually completed.

Another practical inference may be drawn from the case at Sheerness which I may be permitted to mention. Should the flat ground continue for ever so great a distance backward, there can be little doubt that through the whole tract between the fort and the higher ground, water will be found, by boring, every where, that will rise in the wells always to the same level with the well in the fort : for the underpervious stratum must of necessity be continued from the higher ground, or it could not have possibly risen in the well at all.

Another practical inference to be drawn from this case is, that as wells of fresh water are sometimes found to rise to the surface of the ground, or near it, in small islands, that are at a distance from the land, there can be no doubt, but in every case of this sort a pervious stratum, covered by one of impervious matter, must run the whole way from the higher land, under the sea to the island, as at Inch Keith, and Inch Colomb, both in the Frith of Forth ; and that, of course, water will be found

found in that direction every where, if dug for to a proper depth, which will rise to the same level with the well in the island. Hence, if water be wanted on the sea-shore it may undoubtedly there be found.

Again, There are a few instances of abundant springs of good water being found on the top of some small peaked hills, of considerable altitude, which are detached from all other hills by surrounding vallies. In every case of this sort, it must be occasioned by a natural perforation, of the same kind with an artificial tap-hole, which reaches lower down than some part of the valley around, which divides it from higher ground at some greater or smaller distance, having a bed of clay lying above the pervious stratum the whole way. This being the case, there can be little doubt, that every where between the higher ground and that hill, springs will be found by tapping, which will rise to a greater height at first, at least, than the surface of the ground—but it is by no means impossible, that if these tappings be abundant, the well on the hill will be dried up. Indeed, this is not only not impossible but highly probable.—Hence, a  
 fort

fort in that situation, may be very easily reduced to a great distress by a philosophical general who besieges it.—This cannot be done in the low situation of Sheerness; nor will the same reasoning apply in all cases to springs upon detached mountains, where the summit is more flat and of large extent, and the spring of water not very abundant.

Here, also, it may afford satisfaction to some persons to be informed, that the use which is proposed to be made of water sinking from above into internal cavities, for the purpose of turning machinery (p. 158) is not without example; for, there is a mill of this kind, at a place called *Moulins*, (I quote from memory) in the district of Neufchatel, in Switzerland, where the water, which falls into a gulf in the mountain, turns the wheel; the mill itself, and all the machinery belonging to it, being entirely under ground.

It may be here also remarked, that Dr. Derham, having found a spring at Upminster, in Essex, which continued at all times nearly at an equal height, both summer and winter, wished to infer from  
that

that fact, that all springs derived their origin from the sea. This phenomenon, however, has been explained in another manner, by the well near Leith (p. 121) which is a case that is by no means rare. It may, indeed, often happen, that a well of this kind may be found lying directly above another spring of the *tap*-kind, which may be made to rise to a great height above it, and which also shall continue always at the same height nearly. These corollaries are so obvious, as to require some apology for stating them—But when *common things* are represented as *mysterious arcana*, it is proper that the veil which covers them should be, in some measure, withdrawn.

After perusing the above, and adverting that there is not a single principle here illustrated, which was not clearly explained in these Essays, more than twenty years ago—(the single case of draining thin clays alone excepted; all that is added here being only illustrations of the principles already fully enough explained to every philosophical enquirer) the reader is left to judge with what propriety the BOARD OF AGRICULTURE  
has

has prefixed the following exordium, to their account of MR. ELKINGTON'S Mode of Draining Land :

“ It is (say they) a circumstance hardly to  
 “ be credited, that the principles on which  
 “ the draining of land depends, should have  
 “ remained *so long unascertained*, consider-  
 “ ing the great private benefit, and the  
 “ many public advantages, which must ne-  
 “ cessarily be derived from carrying so im-  
 “ portant an art to perfection ! ! ! ”

Mr. Arthur Young, in one of his performances, tells us, that he attended a *seance* of a society of philosophers, in France, who had met for the purpose of improving agriculture, the importance of whose deliberations, and the wisdom of whose remarks, he does not mention in terms of the highest respect.——I am well pleased to excuse myself for not quoting the passage, from my being at present deprived of books.——It would be well if that gentleman would take care to have things so well arranged at home, as not to give occasion for strangers to retort upon our own dear nation, in a similar manner.



**Fig. 32**

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# ADDITIONS

MADE TO THE FOURTH EDITION

OF ESSAYS, RELATING TO AGRICULTURE  
AND RURAL AFFAIRS.

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## *Of the Uses of the Balsam Poplar in Fencing.*

WHEN the First Edition of these Essays was printed, the Balsam Poplar was scarcely known in Britain. It is now sufficiently known, as a healthy free-growing tree ; and, while young, it is particularly attractive, on account of the firmness and luxuriance of its shoots, the grandeur of its large leaves, especially in autumn, and the fragrancy of its buds, in the spring. These circumstances induced me to propagate it in considerable quantities, a good many years ago, —and as it can be multiplied with as much facility as the common willow, by means of cuttings, I was gradually led to perceive

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that

## 178 A NEW KIND OF FENCE

that it possessed certain peculiarities, which rendered it more valuable as a fence, than any of those already enumerated. It has more firmness and stability than the willow—is more luxuriant in its growth than the Lombardy poplar,—and advances more steadily in its progress towards a tree, than the elder; so that, under judicious management, I have found it the cheapest, firm, quick-reared fence for rich lands, in this country, that has ever yet come to my knowledge; on which account, I think it my duty here to describe the mode of management, under which I have found it prove a most useful assistant to the farmer:

For obvious reasons, the person who wishes to avail himself of this kind of poplar, as a fence, should begin with rearing his own plants—and for that purpose the *richest*, mellowest, and tenderest soil he can command should be made choice of as a nursery.—If it has a small tendency to dampness, so much the better—but if it go so far on that side as to be denominated wet land, it will not answer quite so well.

well.—Cuttings from well ripened wood, of two years growth, are best; but where they are scarce, others, older or younger, need not be rejected. The cuttings may be about one foot in length, and should be planted in rows, about eighteen inches distant, and three inches between each plant in the row. Autumnal planting succeeds best; but they will do also in the spring. Their tops should not be left more than one inch above the ground. When they begin to push out their buds in the spring, a careful person should be made to go along each row, rubbing off with his thumb every bud he sees, except one, which in this case will soon push up to be a vigorous stem, without collateral suckers to weaken it. This operation, if carefully performed, will not only make much better plants than otherwise could have been obtained, but it will save a great deal of expence that must have been incurred, had it been neglected.

Nothing more is wanted but to keep the ground clean between the plants, and to dig it over between the rows, at least

## 180 A NEW KIND OF FENCE

once a year ; for the ground for this plant cannot be kept too rich and tender. If justice has been done to it in all respects, the plants, in general, will reach to about four feet in height the first season ; and in two years more, or at the most three, they will be large enough for planting out where the fence is meant to be.

Rich arable or meadow land is that for which this fence is the best adapted ; and as this plant requires to be planted on the flat surface, without any ditch, and can never have the ground on which it is to grow too rich, it will be adviseable, in general, to plough up a narrow ridge where the hedges are meant to be planted, so early as to admit of its being four times, at the least, ploughed, before the time for sowing of turnips. Let it be very richly dunged, and put into turnips, in drills about sixteen inches apart, and properly hoed ; after these are drawn, the ground may be either ploughed or dug, and harrowed smooth, to prepare it for being planted.

The ground being thus prepared, let  
the

## FOR RICH LANDS. 181

the plants (which will now be from 10 to 12 feet high, and from one inch, to an inch and an half diameter at the root) be taken up from the nursery, and carefully sorted, so as to be all nearly of the same size, which are to be planted together. Let a mark be then made in the middle of the ridge, where the centre of the hedge is to be, and stretch a garden line, parallel to that, nine inches from the centre; then let one man with a spade begin to open a hole on the outer side of the line, sufficient to receive the roots of one plant, and let an assistant put the plant into that hole, slanting the top of the plants to an angle of about 45 degrees to the horizon. But, instead of laying these parallel to the line, let them slant so much inwards, as that every plant, at the height of four feet above the surface of the ground, shall be right above the centre of the ridge, and proceeding in that manner, leaving an interval of about one foot, or fifteen inches, between each plant, go round the whole of the inclosure. When this is finished, move the line to the same distance (nine inches) from the middle of the ridge,

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on the opposite side; begin, and proceed exactly after the same manner, to plant another row of poplars, in a direction the reverse from that of the former, so that if the tops of the one row lie to the eastward, inclining to the left hand when you look eastward, the tops of the other shall lie westward, inclining to the right hand, if you still look eastward; so that the two rows meet each other, at the height of four feet from the ground, exactly above the middle of the ridge. The whole row being thus planted, let the tops of both rows be plaited through each other, so as to assume a horizontal position, like the top of a rail; and the fence, when viewed sideways, will have somewhat of a lozenge-like appearance, but not crossed like the willow fence; but with this difference, that the stems are much thicker and stronger in every respect, and that they are not contiguous to each other, and cannot be wattled through each other, unless at the top only. This, then, forms at the very first moment after it is finished, a sort of living railing, of no inconsiderable strength, which, even in this state, will be a tolerable fence, and which  
in



in the course of a few months, will rise to five or six feet in height, so as to be an effectual screen against the severity of the weather, and which in the space of a few years, under judicious management, will have acquired so much strength as to be nearly impenetrable by animals of any sort.

In this way may be reared a hedge that will be a perfect defence against all the larger-sized animals, man only excepted; but, if it be intended to guard against the intrusion of boys, or smaller animals, the following precautions must be adopted:

When the hedge has been completed in the manner above described, let the earth at the roots of the plants be smoothed, and plant a young sweet-brier plant in the opening left between each two of the poplars, so that there shall be the same number of plants of eglantine, as of poplars; but let these eglantine plants be put about three inches farther back than the line of poplars, so that they may be about twelve inches distant the one row from the other. These plants should be of one

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year old, or two at the most, for as it grows very quickly, it will soon reach the top of the hedge.

The first summer after planting, nothing more is necessary than to keep the bottom of the hedge free from weeds; and in the autumn, go over both sides, cutting away with hedge-sheers, all the shoots that come beyond the line of the ribs of the hedge, as the original stems may be called; then raking that rubbish back from the hedge, cut over with the point of the sheers, every plant of eglantine close by the ground, leaving the dead stems that are between the ribs of the hedge, without disturbing them. Next season, the eglantine will send out strong shoots from the bottom, which pushing through the dead branches of the former year's growth, will intermingle with them, and fix them firmly in their place, some of these stems also pushing through among the ribs outwards. In the autumn, once more, cut the sides with the sheers as before; and then, once more, also cut over the eglantine at the bottom, as in the former year. The matting of prickly-brier,  
in

in the heart of the hedge, will now have become very close, so as nearly to fill up the whole of the internal cavity originally left between the ribs; and the next year's shoots intermingling with these, will render it still closer. The sides of the hedge should be clipped every year, and the eg-lantines cut over as above described, until the whole of the bottom part of the inside of the hedge shall become as close as you wish it to be, so as not to suffer a fowl, or any animal of that size, to be able to creep through it; after which time it will be only necessary to cut the *sides* of the hedge annually, so as to give it an external coating of living eglantine, which will form a fence the most impenetrable, as well as the most beautiful, that can be conceived. To add to the beauty, a few plants of honeysuckle may be planted along the hedge, and some of the freest shooting roses, particularly the white rose, interspersed through it, which will thrive abundantly.

The shoots on the top of the hedge may be allowed to run upwards, till they have acquired the size you wish for, or  
have

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have attained to as great a height as you would incline; when they may be cut over, at four feet from the ground, and applied to the purposes you find most useful, or for fire-wood, of which they will afford a very great quantity. After being thus cut over, they will send forth shoots, in general, which will reach to nearly five feet high in one season, and about the thickness of a man's thumb at the under part. In three years, they will be as thick as the wrist, and very tall.

This kind of fence, I have actually reared, and I can safely recommend it as the cheapest, the most quickly reared, the strongest, the most beautiful, the most durable, and in all respects the best kind of fence for rich land, I have ever seen; and I consider myself as fortunate, in having stumbled upon a thing, which for more than forty years I had considered as a desideratum in agriculture, that I never hoped to see supplied, viz. a fence which for the expence of two-pence the yard, at the very highest estimate, can be made so as to be nearly sufficient as soon as it is done up; which can be kept in complete repair ever afterwards,

afterwards, without any expence (for the loppings, in every situation, will be worth more than the expence of pruning them); and which will far outlast the greatest period of human life; being a complete defence, at the same time, against the strongest, as well as almost the smallest noxious animals of every sort.

The intelligent reader will easily perceive why the ribs were made wider at the bottom than above; for in this way alone, could the sides of the hedge be kept alive and close the whole way of the bottom.

I need not add, that, however advisable this kind of fence may be in rich lands, it could not be made to thrive on a poor soil, so that it should never be attempted on such land.

For the uses of the larch-tree in fencing *barren* ground, the reader is referred to the Third Volume of these Essays.

## 188 ON MILL-DAMS, OR WIERs,

*Of the best Method of making Mill-dams,  
or Wiers, Heads, or Breasts across Rivers.*

I KNOW of no species of fence upon which more money is generally expended, than that which forms the subject of the present article; for, though I hope to be able to show that it may be easily effected, yet, as it has been hitherto executed, it is not only expensive on its first erection, but is so liable ever afterwards to sustain damage from floods, that it is a source of never-failing disquietude, and endless charge, to the owners of such works.

Hitherto, it has been customary to make the dike which forms the mill-dam, head, or wier, which runs across a river, universally of a triangular form, being wide at the base, and growing gradually narrower towards the top, where it ends in a kind of point, as in the margin, than which no form can be devised, that could be weaker, or more liable to accidents. The force

force of running-water, when its velocity is accelerated by falling from a considerable height, upon bodies that oppose its motion, becomes nearly irresistible; and, in this mode of constructing a dam, the artist seems industriously to have aimed at giving an example of the power of water, under these circumstances: for no sooner does that water shoot over the uppermost stones of the dam, than it precipitates itself with violence upon those stones on the lower side of the inclined plane, which are made to project beyond the first—but which are thus made to sustain the whole force of that concussion. From one stone it proceeds to another, and another, still acquiring additional velocity, till it reach the bottom of the inclined plane; and, if the height be considerable, it is easy to see that the force of the water, before it reaches the bottom, must have become such, as to be capable of displacing the largest stones that the power of man can place in that position\*.

\* The water too, which rushes through between the crannies of the stones every where, especially where the mound is of considerable height, is so powerful, as to displace the materials in every part, and greatly accelerate the ruin.

Thus

Thus it has happened, and ever must continue to be the case, that every weir which is constructed on this principle of rough unhewn stone, is, from time to time, liable to be swept entirely away, so as to lay the machinery waste until it be again rebuilt ; which frequently happens at that season of the year, when such operations are the most troublesome and expensive.

The frequent recurrence of such accidents has induced some owners of machinery to erect their weirs in a very expensive manner at first, by building the whole triangle of hewn stone, the surface of which is so smooth, as to suffer the water to glide over it, without being able to insinuate itself so readily between the crannies as in the former case. Much good likewise, some are inclined to think, may be derived from giving the surface of the weir a particular form of curvature, which I do not think necessary here to dwell upon. This is, indeed, found to give it some additional security ; but, unless the whole be battled together with bats of iron, it is still found to be insecure ; and the expence, where



where such batting is attempted, is such as to prevent it from being carried into effect, unless under very particular circumstances.

Fortunately, however, for those who have works of this kind to accomplish, by adopting a more judicious mode of construction, they may rear a dam that will be equally strong with the inclined plane, when made of *hewn stone, or even when batted with iron*, at an expence not greater, at least, than would have reared one, of the rudest construction, of common stones.

The reader, from what has been already said, will easily perceive, that the chief circumstances which are wanted to give stability to the dam, are, to remove the stones out of the way of the falling water, so as to free them from running a risk of being displaced by it in its fall, and to prevent the water from being forced violently through the crevices of the mound towards the bottom; he will also perceive, that the first part will be easily effected, merely by making that side of the breast which looks towards the lower part of the river, a perpendicular wall, instead of an inclined plane—for in this case the water, when it is forced

## 192. ON MILL-DAMS, OR WEIRS,

forced over the top of the dam, with the velocity it necessarily acquires when in a flood, will shoot over clear, without touching any part of the perpendicular wall, exactly in the same manner as it shoots over a perpendicular rock, in a natural cascade. This is so obvious, as to need only to be stated, in order to be recognized as unexceptionably just, by every person who shall bestow a single thought upon the subject. It is indeed so obvious, that it must excite some degree of wonder, it should not have been long ago carried into universal practice.

It is not, however, a matter of great difficulty to account for the manner in which mankind have been led into a general persuasion, not only of the *utility* of the triangular form of a double inclined plane, but even of the *necessity* of it, for giving strength to the dam dike. It is very obvious, that if a strong force were applied to one side of a perpendicular wall, tending to push it over, that wall would receive a great additional support, were a strong beam of wood placed in a diagonal direction upon the side of the wall, opposite to that to which the pressure

pressure was applied—it is exactly upon this principle that the buttress of stones, thus applied, has been supposed to strengthen the dam dike—for as the water, flowing forward, apparently tends to force the wall forward along with it, the buttress seemed to be necessary, to enable it to bear that pressure, without being carried away along with it.

But here it deserves to be remarked, that there is a great fallacy in this mode of reasoning, as applied to this case. The strength of a wall for resisting the force of water, depends chiefly upon the absolute weight of the materials of which it consists; and if these materials are of such a form as to make the water press perpendicularly on any part of it, the very weight of that water, if the materials resist the entrance of water, will add something to its solidity. Now, as there is nothing to prevent you from adding as much thickness to the wall, as the circumstances of the case shall render necessary, the buttress on the *under* side may be removed, without the smallest danger of rendering it weaker in any respect;—and, for the reasons already given, it ought most certainly to be removed.

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There is not, however, the same reason for removing the slope on the upper side of the wall ; on the contrary, the farther it is filled up above the breast, and the more gradually it shelves downward there, the firmer it will be : for, as the water presses with a force exactly proportioned to its perpendicular depth, if the mound be broad enough, at the bottom, where the pressure is, of necessity, greatest, there is no necessity of having it broad at the top, where that pressure is diminished almost to nothing. The easiness of the slope, too, is well adapted for preventing the current from striking with great force upon it ; or other objects which may be forced down with the stream, from laying violent hold of it, and tearing it forcibly asunder. Nor is it a matter of great difficulty to make such a mound ; for, as the water above the dam is nearly stagnant, any kind of loose stones, or gravel, or other rubbish that is not soluble in water, will be in no danger of being displaced by the stream, but will lie there undisturbed, if they be thrown in any-how, at random.

These principles being thus explained,

I shall

I shall subjoin a few brief directions for constructing bulwarks of this sort, which, if carefully adverted to, will seldom fail to give satisfaction to those who shall adopt them.

It needs scarcely be observed, that in building this kind of wall, as in every other wall whatever, it is necessary to dig, till a firm foundation be found.—Rock is the best, where it can be reached, for obvious reasons. Where the bottom is only gravel, a wide trench should be made, for a considerable depth, which ought to be, at least, six or eight feet in width. All the rubbish that comes from this trench should be thrown to the *upper* side of the dam. The wall should then be built, two, three, or four feet in thickness, as circumstances shall indicate; the higher the dam, the thicker, always, should the wall be. But few cases occur, in which more than two or three feet are absolutely necessary. The stones in this wall should be bedded with as great care as possible, without any mortar, or with taras at the bottom, especially if any mortar be used, and as few little pin-nings be put in among them as may be.

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And, as it is of great consequence for preventing the waste of water, but still more, for rendering the wall firm and durable, that no water should leak through the dam, the opening that is left on the *upper* side of the wall (which, in no case, should be less than three feet, and, where the mound is high, five or six feet will be better) should be rammed full of clay, regularly as the wall rises upwards. When the wall reaches near to the height that is required, it ought to be brought to a true level across the river, its whole length, and upon the top should be laid a coping of flat stones of as large a breadth as they can be got, and neatly cut, and closely joined in every part (where this cannot be had, or where it is required to project very far, planks of oak-wood may be adopted in its stead). This coping of flat stones should project over the perpendicular wall, on the under side, as far as the nature of the materials will allow; and on the other side, it ought to extend as far as the length of the stones will permit, being so laid as to slope downwards, towards the upper part of the river, in such a manner

ner as that the dipping edge of these stones should be from six to twelve inches (according to their length) lower than the edge which projects over the wall. These stones in the dipping lip ought to rest upon the bed of rammed clay, which should rise higher than their lower lip, and overlap it in part, and if the flat stones cannot be made to join so close as to be water-tight—some clay ought to be laid below them, so as to prevent the water from sinking down through the wall, which is always attended with danger. Small stones may safely be rammed into that clay, and it ought to be covered with gravel, which should rise nearly, but not quite so high as the projecting lip of the coping of the wall. Stones, rubbish, or gravel should be then tumbled down carelessly into the bed of the river *above* the dam, so as to fill it up, as far as can be done at a moderate expence, making it to shelve gradually downwards from the dike into the water; and it will be adviseable, where conveniency permits, to have the whole of this bed to be puddled, so as to make it carry the water through it without  
O 3 sinking.

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sinking. The figure annexed represents a section of the whole when finished,

in which A is the wall ; B the bed of clay, intermixed with stones rammed firm ; C the coping ; D the loose stones and gravel covering the whole, and extending forward in the form of an inclined plane beneath the surface of the water in the dam.

By inspecting this figure, the use of the projecting lip of the coping will be apparent. It serves to throw the water clear over, so as to make it fall at some distance from the bottom of the wall. This distance will be greater when the river is in flood than at other times ; of course, it will have a tendency to make a cavity in the bed of gravel at some feet distance from the wall, so as to be in no danger of undermining it. But should any danger of this sort be apprehended, a row of flat stones (or, for want of these, a plank of oak) placed along the bottom of the wall, leaning towards it at top—and sloping some inches from it below,



below, the under part of these stones being sunk as deep at least as the foundation of the wall, and then covered up with gravel, will effectually secure it. Though this is rather a superfluous precaution.

I beg leave here to repeat, that great care be taken to make the wall, through its whole length, as true a level as possible, that the sheet of water may be spread over the whole of an equal thickness, during the floods, which will tend to moderate its force very much. I need scarcely add, that in laying out the direction of the wall, it should never be suffered to come so near a rock in front of it as to endanger a powerful eddy being thrown back upon the wall to endanger it—this being obvious to every considerate person. Where the head is thus made perfectly level and smooth, it will often happen that the stream of water which flows over it for the greatest part of the year, will be so thin as not to prevent the growth of aquatic grasses near the top, which ought not to be discouraged—for which reason a little mould among the surface gravel (which ought always to be small) will do no harm.

I am aware of one objection to the mode of making dams here proposed (which, indeed, affects all the other contrivances in this Volume) viz. that it is so simple, and so little expensive, as not to be calculated to catch the attention of men, like those vast projects which have the *grand* and *wonderful* to recommend them. It proposes only to benefit those who are attentive to their own interest and a judicious economy. A time may come, however distant, in which these may be deemed objects of great national importance.

It will also be objected, that the stones will be in danger of being *sucked* out of the wall, so as to undermine it, and make it tumble down; this being an accident to which breasts on the modes of construction now in use are extremely liable. It becomes, therefore, necessary that the reader should be here directed to attend to the circumstances which have been here adopted with a view to obviate this evil, that the structure may be so carefully erected as to be in no danger of being deficient in these respects, so as to render the work of no value.

In the first place, you will please to ad-  
vert

vert to the bed of clay, rammed in upon the upper side of the breast; care should be taken that the foundation of this clay bed be dug so deep as to reach the solid bottom—and that the clay *there* be very carefully rammed down, so as to leave no passage for the water at that place, or anywhere else; for if water should force its way through any small crannies towards the bottom, especially where the breast is of great height, it will force its way with so much impetuosity as soon to widen the breach, and carry every thing before it.—It is chiefly because of the neglecting this precaution, that breasts for water are in general so unstable. With a view to give mounds of this kind stability, it is usual to throw in a great quantity of *large* stones in the place that is here occupied by the clay, than which nothing could be more injudicious—for the water always finds an easy passage among these stones—and infallibly must *suck* out, as it is technically called, the lower part of the mound.—This is the unobserved cause of the sucking out of walls, as it is called, which has been commonly ascribed to the eddy from below.—We shall soon have

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have occasion to take notice of other benefits that are to be derived from this bed of clay.

In the second place, the levelness of the top of the breast is of great consequence for giving stability to the work; for by this means the sheet of water, by being extended equally to a great length, is extremely thin in every part, and, consequently, its force is much less considerable than when it is deeper in one place than in another; where powerful streams are formed, which dig out pits below, that are extremely troublesome and dangerous. This circumstance ought therefore to be attended to with great care.—For the same reason, the longer the breast is, the safer it will be, where this circumstance is adverted to.

Thirdly, the coping at top ought to project as far over the wall as possible, and to be cut quite even in the edge.—By this means, the water is made to shoot clear over the breast so as never to touch it, and is of an equal thickness in every part. This is a contrivance that has never yet, that I have seen, been introduced into practice, and from the want of it, much mischief is produced.—

For,

For, where this is wanting, the water in its fall striking on one stone after another, with the accelerated velocity it acquires in its descent, soon insinuates itself among the seams—sucks out the smaller stones, and thus throws down the whole fabric.—The cause being thus removed, the effect, of course, will not be felt.

Fourthly, in consequence of the shoot that the water acquires, the place where it falls at the bottom will vary with the force of the current.—When the stream is low, the water will fall almost perpendicularly down: when higher, it will shoot over to a greater distance; and when it is in a flood it will force itself over to a still greater distance.—But when the water falls down perpendicularly, it has so little force as not to be able to derange any thing—when higher, it acquires more force, and pushes more forward—and when in a high flood, it pushes forward with the greatest impetuosity, and falls at a distance from the breast proportioned to the quantity of the water, and the height of the fall.—It is, of course, at the place it now reaches, that it digs the deepest pit.—Hence, then, it would follow, that  
should

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should the water, when it shoots over the head, alight upon a bed of gravel, it would work for itself a pit, not close by the wall, but at some distance from it ; and that distance would be the greater, the higher the head from whence the water falls, so as to form the bottom of the pool, shelving upward, to the wall, as in the figure ;— thus the foundation of the wall would be in no danger of being undermined.

But should any danger of that kind be apprehended, where the fall is great, and the bottom soft (a bed of clay, for example) it may be advisable rather to prepare a proper basin for the water, than to leave it for nature to form one for herself. With that view, let the bottom be scooped out, as in the figure, so as to make a deep pool, into which the cascade may fall. The depth of this basin may be augmented, by raising a kind of bank of gravel or loose stones before it. In this way all danger of undermining the foundation will be avoided ; the force of the fall being broken by the water, before it reaches the bottom. If the bottom be very soft, a little gravel may be thrown into it, to defend it ; no  
kind

kind of shoeing, where the pool is deep enough, can be required.

There is only one case I know of, where the wall runs a risk of being hurt by the water, after it has made its shoot, viz. when the falling stream strikes upon a shelving rock which inclines towards the wall, so as to drive an eddy back upon it, or make it wheel round in an irregular kind of current. The easiest cure in this case, will be to dig out the rock where it is so circumstanced, and to form a deep pool in its place—the materials taken away can always be usefully employed in making the *bead*. But if, after all, any danger should be apprehended, from any kind of eddy below sucking out the stones, that may be very easily and effectually prevented, by laying a few planks of oak along the whole length of the lower part of the wall, on whose smooth surface the water can take no hold, and behind which the stones will be effectually secured. I need hardly observe, that where any thing of this sort is intended, care should be taken to put some knots of oak into the wall, at proper places, when it is built, for the purpose of securing these planks.

Neither

Neither is it necessary for me to enlarge upon the necessity of augmenting the thickness of the breast wall, where that is required to be made of an unusual height---that being a thing so self-evident, as to be understood by every ordinary mechanic. It may not, however, be improper to remark, that a wall which is strong enough to support the same quantity of loose materials as the mound consists of, that lies on one side of it, is all that is required. This is necessary---but no person of sound judgment will choose to go to the very limits of possibility in a case of this sort---it is always safest to err on the side of excess, so that the wall should be made so strong as to remove all doubt.

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*On the Means of preventing the Sea from  
making Encroachments on the Land.*

WHEREVER water is in motion, it is perpetually producing changes on the surface of this globe, which at times prove highly beneficial to individuals; but more frequently hurtful, seeing the ravages produced



duced by that element, which, when directly opposed, is found to be often irresistible, are frightfully destructive. In the preceding pages, some directions, which have never been found to fail in any one instance where they have been followed, have been given, for securing the banks of rivers from the devastations by running waters. I now propose to add a few hints concerning the most efficacious means of setting bounds to the raging fury of the *ocean*.

The principle upon which the force of water can be effectually resisted, is precisely the same in all cases: so that, in strict propriety, little can be added to what has been already said, farther than to show in what manner the same principle can be so managed, as to apply, with the best effect, to the different cases, as they shall occur.

That water, when strongly agitated, can best be resisted by gently yielding to its influence, and not directly by opposing its impulse, is a truth that cannot be denied, and never ought to be lost sight of in every operation, in which that powerful agent is concerned. In conformity with this principle, it is found, that where the sea-beach

is low, the land is rather, in general, encroaching on the sea than the reverse--- but wherever the shore is steep, the sea is making encroachments upon the land, which are more or less considerable, according to circumstances. Where rocks oppose an impenetrable barrier, they are little altered for ages ; for, although immense masses of rock are sometimes overturned by the raging fury of the ocean, the progress it makes in such cases is so slow, as scarcely to be perceptible ; but wherever the sea approaches a perpendicular cliff of clay, or penetrable mould, it encroaches with hasty strides ; and sometimes carries off whole fields of good land, by the devouring sweep of one furious tide.

To guard against this evil, several contrivances have been adopted, most of which have been so expensive and inefficacious, as to compel those who are sufferers by this misfortune, to be often obliged to remain inactive spectators of the ravages to which they are incessantly exposed. The general mode that has hitherto been attempted to stop the progress of this evil is, to erect a strong bulwark of large stones *in front of the bank,*

*bank*, piling these stones above one another as carefully as possible, so as that the front exposed to the sea, slopes gradually backward towards the bank above, to which it finally joins, at such a height above the sea as the undertakers are able or willing to make it.

Every bulwark of this kind is liable to be destroyed by one or other of the following circumstances, all of which, on some occasions, co-operate, so as to get it thrown down, nearly in as short a time as was required to rear it up : 1st, If an individual has only a share in the property of such a bank, and those on either side of him neglect to fortify their property, the sea, making encroachments at either end, leaves his 'bulwark *there* exposed to the fury of the elements, so as to stand in need of perpetual repairs ; or, 2d, Although this evil should be avoided, the sea, when furiously impelled by a storm, is forced up the inclined plane with great fury, and, when the wave falls back, the body of water that had been forced up, rushes back again over the stones of the inclined plane, with still greater force, like a cascade, so as forcibly to tear the stones out of their places, exactly

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in the same manner that the stones of a mill-dam, of the usual construction, are displaced ; or, *lastly*, the water, in its return, insinuates itself between the stones and the bank at the top, where the stones join to the earth, and there scoops out the earth, so as to leave the stones defenceless from behind, and thus exposed to be tumbled headlong down, by the force of the cascade, occasioned by the revulsion of the tide. Nor is it possible that this evil should ever be obviated, unless the inclined plane of stones should be carried to a greater height than the water can ever be forced to rise, by the accumulated force of a high tide, impelled by a storm ; a thing that, if it could be accomplished by human power, would frustrate its own aim---for the cascade would thus become so much lengthened, as to give the revulsing tide an irresistible power over the stones toward the bottom, that must tear them from their places in a short time, and scatter them about like pebbles on the sea shore. Thus would reason decide on the probable consequences of attempting to secure property, by means of such bulwarks ; and experience has fatally confirmed the justness of

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of

of it, by the example of numberless individuals who have had the misfortune to attempt it.

Wherever a cure is practicable, it must be effected by a procedure, in almost every respect, the reverse of the above. Large stones, instead of being gathered together there, must be carefully removed from the beach; for wherever a large stone is suffered to remain near the sea-shore, between wet and dry, as it may be called, it infallibly produces a whirling eddy, which prevents the sand and gravel from ever attaining that smoothness of surface which, alone can mitigate the fury of the waves, and prevent them from scooping out the earth near the sea-shore. Thus it happens, that wherever many large stones are permitted to remain near the shore, the sand and small gravel, instead of being suffered there to remain till it be accumulated into a solid bed, that gradually rises above the level of the sea, is whirled about by an uninterrupted agitation, among the stones, till it, at last, makes its escape from among them, and is suffered to remain at rest, on some less perturbed part of the shore, and

there to form a bulwark to protect that place from farther encroachments; whereas, that part of the shore where the great stones are suffered to remain, must continue nearly at the same depth, for ages, and suffer the defenceless coast, behind it, to be infallibly exposed to the encroachments of the sea, until that nuisance shall first be removed. By adverting to this circumstance, and carefully attending to the natural operations of the sea, in cases of this sort, we shall be enabled gradually to perceive by what steps the evil complained of may best be guarded against.

When the sea washes down a great body of clay, or other kind of earth that is easily diffusible in water, the whole of that diffusible earth is quickly mixed with the agitated water, and with it is carried far away, until it reaches some place where the water is suffered to remain so long at rest as slowly to allow it to subside. There it forms beds of that soft kind of mud, called *fleetch*, which, when they gradually rise above the surface of ordinary tides, become, in time, covered with herbage, and, at last, form those rich grass lands,

lands, known by the name of *salt-marshes*. While this operation is going forward, the sand, gravel, and stones, which were intermixed among the earth, in its original state, being more weighty than the other component parts of the mould, are deposited near the bottom of the bank from whence they originally came ; and if these materials be abundant, and few large stones among them, the bed of sand or gravel thus accumulated, rises, in time, above the surface of the sea, and forms that kind of natural sea-beach, which is found along the shore, in most places, where no sensible encroachments of the sea are perceptible. But if little sand or gravel be contained in the bed of earth that is washed by the sea, especially if that bed of diffusible earth reaches deeper than the surface of the water, the quantity of gravel or sand is too small to fill up the void that is occasioned by the washing of the sea, and the water continues deep *to the very edge of the bank*. Where this happens to take place, it is a very hopeless case ; and it will be found a matter of great difficulty to effectuate a radical cure—but, fortunately, this is a case

that very seldom occurs ; so seldom, indeed, that I have never seen one of the kind. In general, there is such a quantity of sand or gravel accumulated at the bottom of the bank, as to raise the beach there above the surface of low-water mark, —frequently above the surface of high-water mark, neap-tides ; so that it is only at *spring tides*, or during storms, that damage is sustained. Where this is the case, the evil may be obviated, in most cases, at a very small expence ; and, in no case, will the expence be extravagantly high, if the following mode of procedure be adopted :

Let a trench be first opened in the sand or gravel, ten, twelve, or twenty feet wide, running in a direction perpendicular to the shore, right into the sea. This ditch should not go deeper than the sand or gravel, nor need it be made more than one foot in depth, unless as afterwards excepted, let the gravel be of what depth it may. This trench may be carried out farther or shorter as circumstances shall indicate. As soon as the trench is made, fill it up with earth dug from the bank immediately behind it, taking care to pick out the large stones that  
happen



happen to be among it. Lay this earth so as to slope gradually upward towards the land, rising in a regular slope, with an angle between 10 and 20 degrees from the horizon, continuing the slope in this manner till the top rises higher than the highest rise of tide when agitated by a storm. When this trench has been thus filled up with the earth, taken from the bank—open a fresh trench, of the same breadth, at one side of it, in the gravel, covering the surface of the earth that has just been laid down, with the gravel that is taken out of the trench, so as to cover that new-laid earth with a bed of gravel about one foot deep over the whole. Let the second trench be filled up and covered in the same manner, and so on, till the whole be finished.

If the bank of earth be not very high, and the shore over which the tide flows does not dip much, the inclined plane may be pushed so far forward into the sea, as to consume the whole of the earth that must be taken from the bank, to bring it to a regular slope to its full height. The advantages to be reaped from this mode of procedure, will be, 1<sup>st</sup>, That the earth will thus

be removed at the least expence possible—  
2d, That the gravel will require to be moved to a smaller distance, for covering it, than would otherwise be required; and, lastly, that no ground will be lost, but rather something will be gained from the sea.

But where the shore dips very fast from the beach, it may perhaps be impossible to proceed after this manner, so that the slope must be made chiefly backwards upon the land; and in that case it will be necessary to dig the trench as deep in the gravel near the shore as can be conveniently done, in order that a quantity of gravel may be thus obtained to cover the earth as far back within land as possible.

Please, however, to observe, that the new-made earth will gradually subside, and that the part of the slope which is continued back *upon the solid ground*, will not subside at all; so that if no precautions were adopted, there would soon happen to be a breach at this place, which would render the bank vulnerable.---To guard against this evil, therefore, be careful to ram the new-laid earth as firmly down as possible, especially near the joining; and  
also

also to trench over the surface of the solid bank to a considerable depth under the slope, which will allow the earth there to subside a little, so as to keep them from separating.

The gravel ought to be carried up the slope as far at least as high water mark during the highest tides. Above that, the slope should be covered with a surface of vegetable mould, of as rich a quality as can conveniently be obtained, laid smooth, and sown with grass seeds---so as to bring it to a sward as quickly as possible. Over that should be laid, for some distance, a little gravel, which should become gradually thinner, as it rises higher, till it decreases to nothing. When this bank has become covered with a close pile of grass, such waves as may be accidentally pushed to an unusual height during a casual storm, will flow back over its smooth surface without breaking it. For obvious reasons, no stones or other impediments ought to be suffered to remain upon the surface of this part of the bank.

It will be unnecessary for me to give more detailed directions, concerning the variations that ought to be adopted as circumstances

stances differ, seeing that common sense, where the principle is well understood, will suggest all that is necessary to every attentive mind which contemplates the subject ; and even if a volume were written upon it, there is little probability that all the variations of circumstances, which in some cases may possibly occur, would be adverted to. I shall therefore add no more than barely to suggest, that if the quantity of earth which requires to be taken away, be more than can be swallowed up in making the slope, perhaps the easiest way of disposing of it, after the slope is completed, will be to wheel or cart it down the slope at low water, as far as can be done, and there to throw it down loose, to be washed away by the returning tide---taking special care, in this case, to remove any stones that may be left---and not to allow a high mound there to accumulate.—If the bank be so very high, as to render it an object of great expence to carry the slope as far as the top of the bank, in that case the slope may be discontinued, when it has advanced so far as to be beyond the reach of the sea at the highest tides.---For, under these circumstances,

cumstances, though a part of the cliff may at times fall down merely from the effects of the weather upon it, yet the sea will not there make any farther encroachments upon the land.

In Holland, where the sea dikes consist almost wholly of loose sand, which is nearly in as great danger of being deranged by wind as by water, and where the smallest accident happening to them would prove fatal to many thousand persons, and entirely destructive of their property, they are under the necessity of adopting precautions for securing their banks that our situation renders, in general, unnecessary. In the most vulnerable places, they find the best defence they can adopt against the alternate attacks of the two elements, is to cover the slope of the bank with thatch, which is pinned down along their whole surface with care, in a manner that experience has taught them to be tolerably secure; but, as this thatch is liable to be deranged by various accidents, magazines of it are laid in at convenient distances, and men are appointed to examine the banks daily, along their whole length, each being charged to  
take

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take care, that any derangement in his own division be immediately put to rights. I mention this, here, as a thing that ought to be generally known in this island, though it can scarcely ever be required in the cases of which I now treat---it is chiefly where wiers are attempted with a view to gain land from the sea, as in Holland, that it can be wanted.

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*Curfory Hints on the most beneficial Method of recovering low Land, in certain Cases, from the Sea.*

ON the subject of gaining land from the sea, so nearly connected with that I have just considered—but upon which I do not mean to enter at large in this place, I shall beg leave to suggest a single hint for farther consideration.—It is this : land is sometimes gained from the sea, by gradually rising in its surface till it be above the level of high water mark—sometimes by rising no higher than low water—and sometimes by making an inclosure, and pumping the water out from  
1 a depth

a depth below the lowest tide level, as in some parts of Holland.

In this country, in general, the greatest efforts that are made, have been to recover land that has risen above low water level, but has not reached to the height of high water mark, as in those large works in Bedford, Cambridge, and Lincoln-shires, in which the ground is so low as to be much incommoded by water—and, according to the mode of procedure that has been adopted, it seems to be in no train of ever being better, but perhaps rather worse, if the same system should continue to be followed.

To obtain ideas on this subject, it is necessary to advert, that the extensive marshes here named have been produced by a gradual deposition of mud, continued for ages, which has been carried down by the large rivers which there disembogue into the sea: for the current of these rivers being there met by the sea, occasioned a stagnation of the muddy waters during the full tide, which, while in a state of rest, deposited its mud, and flowed off at ebb-tide much purer than before. The bottom thus gradually rose higher till it got above the

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the level of low water, in which state a few aquatic plants sprung up, and formed those marsh-lands, which naturally attracted the cupidity of men of property around them ; and it became an object of great enterprise, so to shut out the water from these marshes, as to augment their produce as much as possible.

Perhaps something was gained in point of *time*, by those operations that have been there carried on---but I much suspect, that, if the ultimate value of the subject be considered, and the expence at which the alterations that have been made, is adverted to, the loss has considerably exceeded the gain. Nature in her progress, though perhaps a little too slow for the wishes of man, would have effected her purpose much more completely (and probably by this time it might have been fully effected) than ever can be achieved by the feeble operations of man. Experience has discovered, that certain places in those marshes are much deeper than others ; and, consequently, by being below the general level, are of scarcely any value; nor have they any prospect of ever becoming more valuable than they now are.---If  
nature



nature had been suffered to pursue her own course, this would not have been the case. When the rising tide pushes back the muddy waters, these, when stagnant, must assume a level surface; of course, the quantity of matter deposited at the bottom, during still water, must be in proportion to the height of the water above it every where. Hence, where the height of the bottom was within three feet of the surface, if the deposition there was one inch in a given time, where the depth of water was six feet, two inches of mud would be deposited, and three inches where it was nine feet deep. In this way, it is obvious, that the hollow places must have been filled up much more quickly than the shallows. But when it is farther adverted to, that the water would have remained stagnant above the deep places many hours at each tide, while not one drop was above the higher places, it must be evident, that the deposition of mud in the hollows, must have exceeded that on the heights, in a ratio much greater than that which is above indicated. In this manner, nature had a perpetual and invariable tendency to level the surface of this bottom,

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bottom, and gradually to raise every part of it above the surface of the water nearly in an equal degree, so that every part of the field must have been, at last, nearly of the same value. Many millions of acres, the most fertile on the globe, have thus been raised out of water; and immense marshes have thus been filled up, which the weakness of man alone has prevented him from effecting.

The operations of man, have, in this instance, effectually deranged this beautiful economy of nature. Cuts have been made, through which the rivers were to be conveyed to the sea, without being suffered to spread, at any time, upon the marshes. What are the natural consequences of these operations? In the parts of those artificial channels, where the water is made to stagnate by the tide, a considerable deposition of mud is made, which tends gradually to raise the bottom of those rivers; the lowest of which were originally intended to operate; and did in fact operate, as drains to the adjoining fields, and to make it higher than these fields, and thus for a short while only answer the purpose for which they were

were originally intended. Now, although the current where the rivers are considerable, does tend to sweep away part of that mud, at the retreat of the tide, yet a great part of it remains, and this must either be scooped out, at a great expence, or the land be destroyed by hurtful water.

In the mean while, all that mud which is carried forward, past the marshes, by the rapid current of the rivers, now confined to a narrow bed, is repelled by the tide, when it gets past the mounds, and must there gradually accumulate, so as to form a bank beyond the marshes, which, in time, will rise above the surface, and, if permitted, will rise higher than the present low lands, so as to leave them like pits, that must be subjected to a perpetual and heavy charge, to render them good for any thing.

From this plain and obvious reasoning (without entering into the consideration of other particulars, which tend to the same point) the conclusion above drawn seems to be incontrovertible. From that reasoning, likewise, it follows, that the best mode of ever rendering those fields sound land, is to put them under such ma-

nagement as to enable the owners to suffer the waters, when in flood, and, consequently, in the muddiest state possible, to have free access to these fields when they can sustain least damage from it (especially those that are the deepest) and to allow that water to run off, after it has remained stagnant for a short while, for the purpose of depositing its mud. But as the division of property there, will render it impossible ever to get such a bold measure generally adopted, and as it would require stronger mounds, than can, in general, be erected round private property, to render this measure locally practicable, it seems to me probable, that no effectual remedy can ever be there applied for removing this evil.

In the mean while, the progress of nature may be seen going regularly forward on the banks of the Humber; the tide, in which estuary, pushes the mud that is so copiously brought down to it by the Trent, the Ouse, the Darent, and many other rivers, towards the shores every where around it, though with some diversity of progress,

progreſs, according to ſituation and circumſtances, to which it is making continual additions of land, that when it has riſen high enough, is among the moſt valuable which are to be found in the kingdom.

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DISQUISITIONS  
ON THE  
DIFFERENT VARIETIES  
OF  
WOOL-BEARING ANIMALS, &c.

## ADVERTISEMENT.

*THIS Essay was written for the Bath Society, and published in the Eighth Volume of their Memoirs, from whence it is reprinted, with considerable Additions.*



18 Dec 20. EHW.  

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*Disquisitions concerning the different Varieties  
of WOOL - BEARING ANIMALS, and  
other Particulars connected with that  
Subject. Written in the Year 1794.*

**I**T has been hitherto, in general, believed, that the sheep is universally a wool-bearing animal, and that there is no other creature upon the globe that carries *wool*, in the strict and proper sense of the word, but sheep alone. But, there is now reason to doubt if either of these propositions be strictly true.

Among other good effects that will result from the researches of the Society instituted for the improvement of British wool, we have already become acquainted, with the nature and distinguishing peculiarities of a great diversity of *varieties* of sheep, and other animals, that were not before known in Europe. It is to that source we owe an account of the different varieties or breeds of sheep, that have been discovered in the Russian dominions, by the learned

Dr. Pallas, so well known in the Republic of Letters, by his many ingenious Works in Natural History, and other branches of Science; a translation of which into English, was lately published in London. By the same means, we have become now perfectly well acquainted with the Spanish sheep, and its distinguishable peculiarities; as well as with a great many other varieties of the sheep from many parts of Asia, differing from each other in a much greater degree than ever was suspected before, in Europe, was possible.

It would take up too much of the time of the Society, were I to enumerate, in detail, the individual varieties that might be specified. I shall here only briefly state, that (in as far as I yet know) all of them may be reduced to one or other of the three following classes, or the mongrel breeds resulting from an intermixture with each other, viz.

#### CLASS FIRST.

WOOL-BEARING SHEEP, *properly so called.*

THIS class comprehends a great many of the varieties of sheep found in Britain,  
and

and throughout the greatest part of Europe. Sheep referrible to this class, are also found in Asiatic Russia, in Africa, at the Cape of Good-Hope, and in various parts of India.

Among most of the varieties of this class, unless where it has been purified by a careful selection, continued for many years, there is found intermixed with the wool, in different proportions, a kind of short, opaque, brittle, unelastic hair, usually of a dead white or chalky-colour, which is well known to manufacturers, and is easily distinguishable from other hair. It is known by the name of *stitchel*-hair in some places. In other places, it is called *kemps*; and, probably, it has many other local names, with which I am unacquainted. This kind of hair does not loosen from the skin at the same time with the wool, and may thus be, in some measure, separated from it among some of the purer wool-bearing breeds. I have reason to believe, though I am not absolutely certain of the fact, that this kind of hair is peculiar to the sheep of this class, and is not to be found in either of the other two classes, unless where they participate with this one in a mongrel breed.

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### CLASS SECOND.

#### HAIR-BEARING SHEEP,

Whose pile is long in the staple, and of a quality that admits of being employed in many manufactures, nearly for the same purposes as wool.

SHEEP referrible to this class, have been usually confounded with the former, inso-much that they have almost entirely escaped the notice of naturalists and others. The pure breeds of this sort are scarcely any where to be found among *manufacturing* nations; but they are reared, in preference to the wool-bearing sort, among the Russians, and other northern nations, where the skins of sheep, with the fleece on, are used for clothing, as they are found to be much more durable than those which carry wool properly so called. There are, however, a great many varieties among the breeds of sheep in this country, which are mongrels between this class and the former. Here, however, as in most cases where accurate distinctions are wanted, although it seems easy at first sight to distinguish wool from hair, by the crispiness of the former, in consequence

## WOOL-BEARING ANIMALS. 235

sequence of which, it shrinks in length, so as to require to be stretched out before it can be accurately measured, which is not the case with hair in general, yet this is found to afford a rule too vague for accurate discrimination. The following characteristics, may, I think, be sufficiently accurate to be relied on :

*1st*, Wool, like the body-hair of most animals, is an annual production, springing from the skin of an animal. It consists of a great number of distinct filaments, that grow more or less close to one another in different breeds ; but which spring out of the skin about the same time, like corn from a cultivated field ; advance nearly with an equal rapidity, till they have attained their full perfection of growth ; they then loosen from the skin nearly at the same period (when a new crop springs up below) and fall off in large parcels, all at once, so as to leave the body, at one period, nearly bare, or covered only with a short coat of wool. Hairs, on the other hand, (such of them as are of an annual growth only) loosen from the skin separately, and at remote periods from each other, and, unless where they are accidentally matted together,

so as to entangle the loose hairs among those that are fast; they fall off individually one by one, and are succeeded by other individual hairs to supply their place. And as this process goes on through the greatest part of the year, the length of the coat of *hair*-bearing animals, if left to themselves, is not near so different, at different seasons of the year, as that of wool-bearing animals.

Hair, indeed, as well as wool, seems to part from the animal more freely during the spring and earlier part of the summer than in the autumn and winter season; but as the hairs loosen individually, and fall off separately, and as fresh hairs seem to spring out to supply the place of those which have fallen off the moment they are displaced, as takes place with regard to the shedding of teeth among young animals, it must necessarily happen, that the pile, or, as we call it, the fur of soft-haired animals, will be thinner, and consequently less abundant, in summer than in winter; a fact that has been often remarked in regard to hares, rabbits, and other fur-bearing animals, but which has not, to my knowledge, been hitherto fully adverted to. This has  
been,

## WOOL-BEARING ANIMALS. 237

been, in general, attributed to the effect of heat, physically considered ; and hence it has been inferred, that all fur-bearing animals would carry a thin coat of fur in hot climates universally ; a fact that is clearly contradicted by experience. This phenomenon seems to be connected rather with the revolutions of the seasons, like the incubation of birds, and the springing up of certain plants and flowers, at particular seasons of the year. The fleece appears indeed to be very thin during the warm season, but this is not so much because there are fewer hairs in it, but because many of these hairs are then so short, as to contribute little to the weight of the pile ; whereas, in winter, these short hairs have become longer, and thus thicken the pile by growing up among the longer hairs that have adhered to the skin during the whole of the summer season. This hypothesis seems to be strongly confirmed by a fact respecting furs that has not hitherto been much adverted to, which, I have reason to believe, prevails very universally, viz. that if a lock of the hair taken from any  
kind

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kind of fur, be held by the points, and combed the reverse way, a much greater proportion of it would always be combed out, than ever happens with regard to any kind of *wool* if treated after the same manner. Hence, I am, at present, inclined to infer, that this great diversity in the length of the different filaments in the same pile, is a distinguishing characteristic between hair and wool, let the fineness of each be what it may. I speak at present, however, only hypothetically, for I have not had opportunities sufficient to observe these facts to enable me to speak with *certainty*.

2dly, A filament of wool has no determinate proportional thickness in its different parts, but is variable in all possible proportions. Sometimes, the root-end is thicker than the points; sometimes, and indeed for the most part, in this climate, the points are thicker than the roots; sometimes, the middle is thicker than either end; sometimes, it is quite the reverse; at some times, the variation of thickness is great, and extremely perceptible; at other times, the filament is of an equal thickness throughout



throughout all its parts. These variations in regard to the thickness of the different parts of a filament of wool, have been proved, by experiment, to depend upon the degree of heat or cold that has acted upon the animal at the time the filament was in its state of growth ; that part of it which grew during the influence of a continuation of warm weather, being always thicker than that part of it which grew during cold weather ; the difference of size varying with the difference of temperature, in all proportions, the size of the filament continuing the same only where the animal has been kept in an equal temperature of heat during the whole period of its growth.

Hairs, on the contrary, seem to have always a determinate shape and relative proportion, under whatever circumstances they shall have been produced—one species of hairs being of one shape and proportion, and another kind of another shape. In general (and with no exception, that I know of) the body-hairs of animals are thickest at the root, and taper sensibly towards

wards the point, which is directly the reverse with all wool of grown sheep in this country\*.

By

\* I find reason to proceed with great caution in this Disquisition, because I have not had opportunities of observing facts with the necessary precision to enable me to deduce general conclusions with the certainty I wish to do. The observation in the text is just, as far as respects the common breeds of animals that are reared in this country; but since the above was written, I have seen reason to believe, that there is a much greater diversity in this respect, than I suspected at the time that paper was written. Before that time, I had often remarked, that the kind of hair called *kemps*, which grows among the wool of our sheep, is always thicker at the roots than at the points; from whence I naturally inferred, that all kinds of hair that grows up among wool, was always of the same sort. I now find that this is not the case; for the native sheep of Jamaica, which carry a considerable proportion of very fine wool, bear, at the same time, a kind of hair, intermixed among that wool, which is totally different from the *kemps* among our wool, in many respects; in particular, it is *invariably* much thicker at the points; that is to say, coarser, of greater diameter, taking each hair individually, than at the roots. It is also uniformly of a greater length than the wool, so as to cover that wool over the whole body, which is directly the reverse with *kemps*. Each of these hairs of the Jamaica sheep is marked from the point downwards with transverse rings, of short diameter, that  
are

## WOOL-BEARING ANIMALS. 241

By these two criteria, wool may be, in general, distinguished from hair, where

are alternately black and white, so as to give it very much the external appearance of badger's hair.

I find reason, also, to be satisfied, that the form and external appearance of the hairs of different animals differ greatly from each other. Among those which have fallen under my own observation, the hairs of the *musk* animal (a fine skin of which I saw in the possession of Mr. FORSYTH, at Kensington) is, perhaps, the most uncommon I have seen. These hairs are stiff, and approach, in part, to the nature of quills, though they are much softer and more flexible than those of the hedge-hog or porcupine. They draw to a narrow point, and are much thicker at the root. Each hair has the appearance of being a flaccid tube, and is a little twisted, somewhat in a spiral form, so as to have a slight appearance of a rope.

Hairs differ also from each other in respect to the manner in which they are placed into the skin. The most beautiful variety of this kind I have seen, is that of the great polar or white bear, the hairs of which are placed all over the skin in tufts, with bare places between, exactly like the bristles in a clothes-brush. These are placed in rows with the most perfect regularity, like cabbages planted with the utmost precision in a garden, so that when the skin is folded back, either across the body, or lengthwise, or diagonally, the skin is discovered clear between them, in regular rows. Other variations, I have no doubt, take place in regard this particular, that have never fallen within the sphere of my observation.

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they are entirely uncompounded, without difficulty. But as all the different varieties of sheep breed readily with each other, and produce a mongrel race, in which the discriminative qualities of the parents are blended together, it necessarily follows, that where the mongrel breed is produced between a wool and a hair-bearing race, it will afford a fleece that can neither be distinctly characterised as hair nor as wool, but will participate of the qualities of both. If this mongrel shall mix again with a wool-bearing race, the fleece of the descendant will approach nearer to wool; if with a hair-bearing race, nearer to hair; and so on, they may be blended *in infinitum*. By this means, the distinctive characteristics of hair and wool may be, in time, entirely lost, and fleeces be produced that are neither the one nor the other. This seems to be precisely the case with most of the breeds of sheep in Britain at the present day; and we must go, in some measure, out of the island, to recover the genuine breeds; but which, if attended to, will enable us to account for various phenomena that have puzzled many intelligent men.

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## WOOL-BEARING ANIMALS. 243

The most uncontaminated breed of wool-bearing sheep I have as yet met with, is, the Shetland breed ; and there the wool rises so entirely from the skin, about the beginning of June, as to render the shearing of their sheep unnecessary. It may be plucked off at that time without occasioning to the animal the smallest uneasiness, as it will fall off of itself, if not taken away ; the young fleece springing up beneath it, like a young shorn fleece. The same phenomenon is observable in all the breeds of sheep in the northern parts of Scotland, where the proper time for shearing is always indicated by nature, and must be attended to. For although these sheep have got such an intermixture with the hair-bearing race as not to allow it to loosen quite so entirely as that of the Shetland breed ; yet it is loosened to such a degree, that if the sheep are shorn too soon, and before the wool is properly *risen*, as the phrase there is, it is difficult to pass the sheers through it, and the skin is left very bare, the young wool not being yet grown. On the other hand, if that shearing be too long delayed, the young wool has grown to such a length as to en-  
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tangle the sheers in it, so as to cut off a part of it, which is both troublesome to the sheep-shearer, and when it is thus shorn, the wool is useless. But when the wool is risen to its proper state, the sheers slide over the young fleece, and cut off the few remaining hairs of the old fleece with the utmost ease, so that the sheep discovers no marks of being new shorn, and looks like a lamb in that respect.

It would seem that there is a much greater proportion of the hair-bearing race among the breeds of sheep in the southern parts of the island; for I observe that Mr. LISLE, who lived in Hampshire, and was an attentive observer, though he had heard of this young wool, under the name of *rowety*-wool, had never seen it. It is well known in Scotland, that this phenomenon does not depend on the leanness of wool-bearing sheep, as he supposes, but takes place among those that are in the best condition soonest\*.

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\* I find that most people have an idea, that the phenomenon of young wool rising at the bottom of the fleece of sheep before shearing, and all the peculiarities here mentioned, are entirely occasioned by a check the sheep have received from a want of food in the winter:

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The purest of the hair-bearing sheep I have seen, were some fleeces that were sent to me from the Baltic, which were as evidently hair as the fleece of a goat, though finer and softer. The Russians prefer this breed of sheep, because the fleece, when at its full length, adheres so much more firmly to the skin than wool does, that it lasts much longer when made into clothing than the other; for which reason, a wool-bearing sheep among them is a great rarity.

Among the sheep referrible to this class, there are some breeds which afford a small quantity of a very fine soft wool underneath the hair, of which the *Argali* of PALLAS

to this opinion I cannot accede, for the reason after-mentioned; though I know well that when a sheep has sustained a great stress of weather during winter, it does happen that the old fleece sometimes separates prematurely from the skin; but in that case the fleece becomes matted, and assumes an appearance extremely different from the natural healthy rising above alluded to. In this last case, the wool does not separate in the early part of the spring as where it is matted; but it adheres to it till the month of June at least, and even then it loosens in a gradual manner, as the young fleece begins to rise, and always soonest upon the sheep in the best condition; which, on that account, are often shorn ten days or a fortnight sooner than the others.

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is a noted example ; but the greatest part of the varieties we know have none of this. I have never heard of an unadulterated breed of this kind that had stichel-hair among the fleece, though it is often found among the mongrel breeds between this and the former. Neither have I ever heard of a finer kind of wool being found at the bottom of the fleece of any of the wool-bearing breeds.

The very long wool of Lincolnshire, which I have examined with care, appears to be from a mongrel race, very nearly allied to this class, with a small blend of wool in it ; and is of a harder feel than some of the pure hairy breeds, some of which are tolerably fine and soft, and very tough and durable in work, and have a fine glossy silky-like appearance. I have had wool, of the genuine wool-bearing breed of sheep, that measured  $17\frac{1}{2}$  inches in length, which was extremely fine and soft, and nothing resembling that hasty kind of hair-wool in Lincolnshire.



## CLASS THIRD.

*SHEEP that carry SHORT THICK HAIR, which in no respect resembles wool of any sort.*

OF this variety of sheep-species we have no breeds in Britain; but that such sheep do exist, we have the clearest proofs. So little are they known, indeed, in this country, and so little is it suspected here that such an animal exists, that I was not a little surprised when I first saw one of this kind, and therefore examined it with a good deal of attention. This creature was on board a Danish East-India ship that put into Leith-roads last season [1794] and was bought, with several others of the same sort, as they assured me, in the island of Madagascar. It was a ram of a good size, and was covered all over with a thick coat of short thick stiff hairs, like those of a horse, but rather stronger in the pile, and shorter. The colour was a fine brown, The hair lay close to the skin, and was very smooth and glossy, like the coat of a well-

dress'd horse, in fine order. They assured me, it had never had any other covering on it but what I saw, and that all his companions were of the same sort.

This fact threw the subject of sheep into a new point of view, that I had never adverted to before; and enabled me to account for some phenomena respecting sheep, that had puzzled me a good deal. In the account that Dr. PALLAS had given of the famous Boucharian lamb-skin furs, some of the peculiarities he mentioned appeared to me to be incompatible with the nature of wool, and much more nearly allied to that of hair. But, as I had no idea that any sheep of this kind existed, I was perplexed about it, and could come to no decided opinion respecting it. Since then, I have had an opportunity of seeing a nightgown, lined with Boucharian lamb-skin fur, which, I find, consists of nothing else but *hair*, without the smallest intermixture of wool. It is somewhat longer than the Madagascar sheep's hair, softer, and gently waved by means of a little curl upon it, which gives to it the beautiful foliage-like appearance for which these furs have

have been so much valued; so that this forms a second variety of this class of sheep.

While I am just writing, I have received a letter from Sir JOSEPH BANKS, bart. on this subject; who says, “I once imported  
“three sheep from Spain, which were as  
“fleck and smooth as a horse, and never, at  
“any season, showed the least sign of wool  
“or down in the most minute quantity.” The fact, then, is incontestibly established, that sheep which produce as little wool as horses, do exist; and, perhaps, they are much more common than we at present suspect. The Boucharian breed of sheep is kept in immense flocks, over the extensive plains of Great Tartary. I have been also assured, of late, that they have a breed of this kind of sheep in the island of Antigua.

And last winter [1796-7] I saw a sheep of this sort, in a field near Dulwich, in Kent, within three miles of the metropolis, feeding quietly, and very tame—so as to suffer me to come quite close up to it, to examine the hair. Where it had come from, I could not learn; but, it seemed to

be a different variety from the Madagafcar sheep I had formerly seen. In colour, in particular, it was very different; the Madagafcar sheep being of a clear glossy brown, this one white, with a few dark-coloured spots upon it. So that this kind of woolless sheep seems to be by no means rare. I am assured, that the greater part of the sheep in India are of this sort, though there are also many of the wool-bearing race to be found in those regions.

A natural inference from these facts is, that since we find one class of animals, some breeds of which produce wool, and other breeds produce nothing but short hair, in no respects resembling wool, may not a similar diversity take place in regard to other classes of animals? And although it should happen that the inhabitants of one country should be possessed only of the hair-bearing breed of creatures of that sort, like the Madagascarese sheep, and know nothing of any other sort; yet, there is no reason, from that circumstance, for them to conclude, that no other breed of that kind of creature exists. This train of reasoning being suggested, it roused the mind to attend

tend to facts ; and I had soon occasion to observe, that so far from having reason to be surprised at finding breeds of sheep so much diversified, as above set forth, there were innumerable well-known facts, which, if adverted to, would have led to the same conclusion.

For example : there is no man in Britain, who has not had occasion to observe as great a diversity in regard to the coat of dogs as of sheep.

1<sup>st</sup>, The smooth-haired dog ; examples of which, are, the Italian greyhound, and Spanish pointer.

2<sup>dly</sup>, The long-haired, soft, wavy-fleeced dog ; as in the English spaniel, and Newfoundland dog.

3<sup>dly</sup>, The wool-bearing dog, or, at least, the dog that carries a coat, which for closeness, length, and softness, may be compared to wool, is very common. Some of them carrying an immense quantity of hair, of a long lank quality, and others carrying it of a close curled texture, very like the fleece of many kinds of sheep. The fleece of these creatures must be shorn at the beginning of summer, to let them be com-

fortably cool; and I have seen it spun and worked into stockings, which could not be distinguished from wool.

I have in my possession at present, some of the hair of a dog of this kind, that I found in London, belonging to a blacksmith, which is soft as wool, and which I find has among it a few hairs resembling, *in every respect*, that kind of hair called *kemps*, which has been hitherto deemed quite peculiar to the sheep kind.

N.B. There is a kind of fox, in Siberia, that carries a fur exactly like *wool*, as I have been assured by a gentleman who lived long there. The Russian name of it, being literally translated, is, *the little dog's fur*.

The same diversity is observable in regard to goats: as,

1<sup>st</sup>, The smooth short-haired goat, very common.

2<sup>dly</sup>, The long-haired shaggy goat, very common also. The hair of this kind of goat is usually very coarse; but underneath it, as in the long-haired breeds of sheep, there is a quantity of wool, of an exceedingly fine quality, which may be separated from

from it about the month of June, by combing. From this circumstance, it would seem that this wool, like the *wool* of the sheep, rises from the skin, and becomes loosened from it, while the hair still adheres firmly to it. Of the fineness of the quality of this kind of wool, you may satisfy yourself, by examining the small shred of a little web that will accompany this, of that kind of wool, which was manufactured under my eye here last summer. There was as much of it as made three full-sized shawls and a waistcoat-piece, from whence the pattern sent was cut. The chain is silk, as there was too little materials to make it of wool. These shawls were compared with the finest India shawls that could be found in this place, and were deemed softer than any of them. The shawl-wool in India is precisely of the same nature, and is obtained from the Thibet goat. I have examined some Thibet goats in this country, and find their hair rather longer and coarser than the common European goat, from which it differs little. If it was a fair specimen I saw, the *wool* was rather less

less abundant on these than on the common goat.

3dly, The wool-bearing goat, for so I think the Angora goat may be called, whose hair is as fine, as soft, and as fit for work, as almost any wool; but whether it *rises* like wool, or is in this respect like hair, I have had no opportunity of observing. A specimen of Angora goats-hair, produced in Britain, will accompany this.

Whether there will ever be discovered the same diversity of hogs, I cannot tell; but we already are acquainted, in Europe, with something analogous to the two first-mentioned breeds of sheep, viz.

1st, The smooth short-haired Chinese breed. The Jamaica breed of hogs belongs also to this class.

2dly, The long-haired breed, having wool under its long bristles; of this kind, is the small breed of hogs found in Orkney and the Shetland Isles. Its bristles are very long and shaggy, and under them is found a very abundant quantity of wool, which is soft; but its peculiar qualities have not been as yet sufficiently investigated. I have  
hitherto



hitherto heard of no breed of hogs that carries wool only.

Hence it appears, that the diversity of animals that carry *wool*, is much greater than has hitherto been in general suspected; nor can we at present say, with any degree of certainty, that there may not still exist, in some corner of the globe, one or more of every species of domestic animals we are now in the custom of rearing, and that do not carry wool with us, which may also carry wool, as well as some varieties of the sheep. And since it is well known that the inhabitants of Europe have derived great advantages from selecting the *wool*-bearing breeds of *sheep*, and rearing them in place of the smooth-haired sort; it is equally certain, that, could we discover any varieties of the other domestic animals of the smooth-haired kinds, that we have been accustomed to rear, which should afford *wool* as the sheep does, the benefit we might derive from substituting these wool-bearing breeds, instead of those hairy sorts we now propagate, would be very great, if their qualities in other respects be nearly the same.

Of

Of all the varieties of domestic animals we have been accustomed to rear in Europe, next to the sheep, the bullock is the most valuable. We, it is true, like the inhabitants of Madagascar with regard to sheep, have been hitherto in the custom of rearing the smooth-haired bullock only; and though, perhaps, like the inhabitants of Madagascar, we may have accidentally heard that there are some varieties of this class of animals that carry something like wool, in other parts of the world; yet as these have never come to our door, and presented themselves to us, we either doubt if such animals do exist, or conclude they would not thrive with us, and therefore sit still, contented with what we have, without making any efforts to better ourselves. Is it not a well known fact, that we have continued for more than a hundred years past to import wool from Spain in great quantities every year, without ever once attempting to rear the breed of sheep that produced it, though they were in a manner at our door? And is it not also known, that instead of making a fair experiment to ascertain

certain with precision whether that wool could be produced here or not, writers have been squabbling with each other about the possibility of a thing which could never be proved *pro* or *con* by reasoning, but by fair experiment only? And is it not also a fact, that although it be now proved to demonstration, by repeated experiments, that the wool of sheep brought from Spain, does not degenerate in Britain, there has been, till this hour, no attempt made to obtain a single individual of the *finest* breed of sheep from Spain? And is it not also a fact, that because those sheep that have been brought over from Spain, at random, have not been so fine in the carcase as some of the selected and improved breeds of sheep in Britain, that different persons are still disputing about the possibility of having sheep with a good carcase from Spain; as if a fact of this sort could be ascertained without accurate trial and experiment? Thus do we sit in our elbow-chairs, and argue, without data, till we reason ourselves into indolence and inattention, that make us remain contented with the dregs only of what  
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might easily be within our reach. To men in these circumstances the words of the poet may be applied:

O leaden-hearted men, to be in love with death!

It is most certain, that the person who ventures to rouse the attention of men to the investigation of facts which they have not been accustomed to take notice of, must inevitably expose himself to the sneer of ignorance; but that is of little consequence, if it should chance to throw a single ray of light upon a subject that has been hitherto involved in darkness.

That there is nearly an equal diversity of breeds of cattle as of sheep, scarcely admits of a doubt; of which the following facts are proofs:

1<sup>st</sup>, The short smooth-haired breeds. Of these, the shortest I have seen, is a bull, of the *Zebu* kind, that was lately exhibited in Edinburgh, as a show. His hair did not exceed half an inch in length, and was very close, firm, and elastic. There are many breeds of cattle in Britain, the Holderneffe in particular, the hair of which is short and very smooth.

2<sup>dly</sup>,

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2dly, The long soft wavy hairy breeds. Of these the Lancashire cattle are a good example; and many of the Highland breeds, some of which have manes like horses.

3dly, The long soft wool-like bearing breed, of which the buffaloe, or rather bison, of Louisiana, is the chief. The hair of this animal is said to resemble clothing wool, in length, in thickness, and in closeness; a small specimen of this wool is inclosed, which I received from Sir Joseph Banks, bart. But as the creature has never yet been domesticated, or subjected to particular observation, by men whose judgment could be relied upon, our notions of it are but very imperfect. I do not hear that there are any long hairs upon this breed of cattle.

4thly, The long-haired wool-bearing breeds. Belonging to this class there are three varieties, obscurely known, viz.

1st, The *Sarluc*, by some naturalists called the grunting ox, an animal of the Southern Tartary, which is not yet sufficiently known. The fleece of this creature  
is

is said to be thick and long, falling down below its knees, and of a very fine quality.

*2dly*, The Chittigong cow, of the higher Hindostan, which is described nearly in the same terms.—Its hair, or wool, is much esteemed by the natives, and is applied by them to various purposes.

*3dly*, The Musk ox, of Hudson's-Bay. This animal is much better known to me than the former, as I had the description from a gentleman in Edinburgh who lived many years in Hudson's-Bay, and who had seen thousands of them, dead and alive. The whole body of this creature, which is rather less than a middle-sized ox with us, is covered over with a very close fleece of long, soft, flexible hair, of a fine quality, which might be employed in manufactures for many of the same purposes as wool. Beneath that hair, and towards its roots, lies another coat of exceedingly fine wool, which could be applied in fabrics of the finest quality. It has been spun and worked into gloves and stockings, which are said to be as soft as silk. The buffaloe-wool inclosed, I showed to the gentleman, who

said

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said it was nothing like so fine as that of the musk-ox.

The flesh of this kind of ox is very fine, unless at the rutting season, when it acquires a musky flavour, from whence its name. Herds of many thousands of them are to be found up the country, among the Esquimaux, but none of them have ever yet been domesticated. They do not seem to be either so wild or so ferocious as the wild breed of European cattle that are still kept in Whittingham-park, Northumberland.

To show what practical uses may be derived from these facts, I shall beg leave to subjoin a few farther observations on subjects connected with this, that have resulted, in some measure, from the enquiries which have been set on foot by the wool society :

1<sup>st</sup>, It is now ascertained, that all the varieties of sheep yet known do readily intercopulate with each other, and that the progeny is a prolific animal, capable of continuing the species ; but that in respect to its characteristic qualities, it is of a *mongrel* race, participating nearly alike of the

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qualities of both its parents. And as these mongrel breeds may be intermixed with other varieties *in infinitum*, it may in many cases happen; that new mongrels may be produced, in which the distinguishing peculiarities of the original breeds may be blended in all possible proportions, and lost.

In like manner, the varieties of dogs may be blended and lost, if no care be taken to preserve them; and so of cattle: At least, we know for certain, that the different European breeds may be so; and we have reason to believe, that the buffaloe, the zebu, and the other varieties that have not yet been tried in Europe, may be blended together.

2dly, The effects of climate and food, in altering the qualities of the *breed*, are found to be nothing; though the effect of these things upon the individual creature that is subjected to their influence, may, in some cases, be very perceptible. For example:

It has been shown above, that the wool of *wool-bearing* sheep is affected by heat or cold; but this is nearly in the same manner as heat or cold affect the mercury in



in the thermometer. It is a momentary impulse, which ceases to operate the instant its influence is withdrawn; and the animal, which may have been made to undergo great variations of heat, returns to its former state as soon as its original temperature is restored. But even this variation seems to be felt only by the *wool-bearing* breeds; and is, besides, of much less powerful influence than has been usually supposed. Nor is there a single fact, that has ever been discovered, that gives the smallest countenance to the generally-received opinion, that heat tends either to make the fleece thinner in pile, or to encourage the growth of hairs among it; far less, that it operates, as M. BUFFON and his followers assert, in producing permanent changes on the descendants of the animals.

Heat likewise tends to accelerate the fattening of some animals, to whom it is congenial; as the hog, to an astonishing degree.

Richness of pasture also tends to produce temporary changes. On the wool: there is reason to believe it tends to augment its

length *in some degree*, though but a little : it adds to its softness and toughness ; but, in regard to coarseness or fineness, no fact has as yet been found to ascertain that it has any sensible effect, though I am aware that *opinions* are here as decisively adopted, as if the facts had been fully ascertained. On the carcase : abundance of food is well known to augment the size of all animals to a certain degree, when compared with scanty feeding. A scarcity of food, approaching to the state of starvation, is also well known to render the wool which grows at that period of starvation, brittle and unelastic.

3dly. The influence of breed, in propagating the qualities of the parent stock, or in altering the qualities of it at pleasure, by blending it with others, may be said to be all-powerful. There is not a single fact, that I have ever been able to meet with, properly ascertained, which tends to show, that the distinguishing peculiarities of any breed of animals can be sensibly changed in its essential characteristics, by any change of climate, or any other circumstance, except an intermixture of blood alone ; but innume-

rable facts may be found that ascertain the contrary. The Persian and Arabian breeds of horses brought into Europe, are only changed by intercopulating with other breeds. The Chinese hogs may be continued for ages unchanged, if no crosses be permitted. These facts are notorious; and every other fact upon this subject tends to establish the same conclusion.

*4thly*, Although the same breed of animals appears not to be liable to be changed by climate, or other extraneous causes, yet it is found by experience, that individuals may be met with, among every breed of animals, which are, in some lesser circumstances, different from others, though they still possess the general characteristics of the parent breed, arising from circumstances that have hitherto eluded our observation, and which it therefore exceeds our power either to accelerate or to retard. So strong also is the propensity of nature, in all cases, to produce its own kind, that if the individuals possessing these qualities, thus, as we would say, accidentally procured, whether beneficial or hurtful, be selected and put to breed with others that possess

qualities somewhat of the same sort, it is found, that the descendants of these selected animals will, in general, be possessed of the distinguishing peculiarity for which they were selected, in an eminent degree; though among these also some individuals will be found to have less of it than others: And if these least approved individuals be banished from the selected stock; and those, both males and females, which possess the wished-for quality in the most eminent degree, be put to breed together, the descendants of these will be still more improved: and by continuing this mode of selection for a great length of time, the improvement, as to this particular quality, may be carried to an indefinite height. In this way, may be produced an improved breed; which, though agreeing in the general characteristics with the parent stock from which it was selected, may possess some peculiar qualities in a much higher degree than it does.

It is of much importance to the practical farmer, to advert to this peculiarity in the economy of nature, because it puts it very much within his power to benefit himself,  
by

by attention and care, in regard to circumstances that would otherwise seem to be entirely beyond his reach. For were he to be persuaded that certain peculiarities he wishes to obtain, are necessarily dependant upon a temperature of climate he never can enjoy, or that certain bad qualities in the animals he breeds are inseparably dependant upon the nature of his pasture, which it exceeds his power to change, he must of necessity sit down contented with what he has, without a hope of improvement; but if upon examining the facts above stated with attention, he shall find that the influence of breed is so powerful as is there stated, he will be at pains, in the first place, to look around him, to see if he can discover any breed possessing qualities, upon the whole, more valuable than his own, which is found to subsist on pastures of a quality not better than his own; and when he has once found them, continue, with uninterrupted attention, to select the best in all respects, particularly those that thrive best among them, to breed from. This has been done by Mr. BAKEWELL, and those who have adopted his system, with such success,

as not only to establish the principle for which I contend beyond a doubt, but also to give room for encouraging others to adopt a similar plan for improvements in other respects, than those that seem, hitherto, to have come within the compass of his plan.

5<sup>thly</sup>, There seems to be no reason for believing that any one peculiarity we may be in quest of, is necessarily connected with, or dependant upon, any other peculiarity in the animal creation. For example: The improvers of live stock, in the present age, hold it out to view, as a general principle, that a facility in fattening is invariably connected with certain peculiarities in shape; and of course they conclude, that, wherever these peculiarities of shape are to be found, the facility of fattening will be found also, and the reverse. This, I contend, is a false principle, and I venture to say, that when the facts shall come to be thoroughly investigated, their conclusion will be found to be erroneous; indeed it is in some degree departed from in *practice* already, though in theory the principle is still adopted, without limitation. A few years ago, shortness of leg was deemed a point indispensable

dispensably necessary in a feeding beast, and it went the length of almost being deemed—the shorter the better: this is now no longer contended for. Many of the characteristics of the present day will, in like manner, gradually fall into disuse, as people come to open their eyes on this subject. The fact is, I have seen animals that had a powerful tendency to fatten, which are almost, in every respect, the reverse of the shape most highly esteemed at present, and the contrary. And by referring every person who has had opportunities of observing *many breeds* of the same kind of animals, to his own experience, I have no doubt, but he will easily recollect instances of the same kind; or, at least, if his mind be unprejudiced, that he will soon have occasion to observe it. To that experience, then, whether past or to come, I refer on this occasion.

One circumstance, however, it is necessary here to advert to, viz. that as the breeds of animals from which the selection was begun, were originally of very good kinds, and chanced at the same time to possess those shapes that are now deemed so essentially

tially requisite; and as the improved breeds that have been selected from these are found to possess those shapes, it is by no means an unnatural conclusion to infer, that these shapes are in some degree inseparably connected with the propensity to fatten easily. Had it chanced that equal pains had been bestowed upon selecting from another good breed that was differently shaped, the prejudice would have been equally strong, in favour of that shape. But as the breeds that have been hitherto the object of selection, have got the start of all others in point of improvement, it is probable the prejudice in favour of their shape may long continue to prevail; nor do I wish it to be understood that I have any prejudice against the shapes recommended. Far from it, for I think them very beautiful—I only wish to say, that that circumstance is not *essentially* connected with the other; for as every error, when admitted as a truth, leads to unforeseen and often pernicious consequences, though the opinion objected to may not be of much consequence in the particular instance now under consideration, its influence



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may be very unfavourable in regard to others. Allow me to add one farther illustration on this head, before I put an end to this long paper :

If it be admitted, that a faculty of fattening easily be necessarily connected with certain peculiarities of shape, merely because it chanced accidentally, as I will say, that these two peculiarities happen to be united in that breed of animals which has been brought forward to notice; we ought, by the same mode of reasoning, to infer, that that quality of fattening easily, is as necessarily connected with coarseness of wool, or lightness of fleece, or any other useless or hurtful peculiarity, if it should so happen that the favourite breed chanced to have coarse wool, or a thin fleece, &c. The consequence of this conclusion would be, that every man who wished to improve the carcase of his sheep, would turn away from every breed of sheep that carried fine wool or a close fleece, as he now does from those breeds that have long legs, or what is deemed in other respects, improper shapes; and fine-woolled sheep, carrying close fleeces, would come to be entirely neglected. But  
if,

if, instead of this prevention, he should be convinced, that it might be very possible to find a sheep that would have a tendency to fatten kindly among those breeds that carry very fine wool and close fleeces; he would be as anxious to select from these breeds, as from others; and probably as successful too, if he had set out at the same time, with the man who began to select from the coarse breed. I am, myself, perfectly satisfied, from a variety of facts that have fallen under my own observation, which would fill a volume nearly to enumerate, that fine wool, for example, is neither necessarily connected with thinness of pile, (the Spanish sheep carry the closest pile of fleece yet known in this country) with shortness of staple (I once had a fleece of wool, that measured 17 inches and half, which was finer than the best Spanish-wool I could buy in London, and extremely soft) with tenderness of constitution, with a tendency to fatten slowly, or with any one quality that can be named, though it may be *accidentally* connected with these: And I have not a doubt, but when the eyes of mankind in general shall be opened, so as  
to

to admit of their examining the facts that fall under their notice, without prejudice, they will be able, in time, to select breeds that shall be distinguished not only for *one* valuable peculiarity, to the exclusion of all others, but even to obtain that valuable peculiarity conjoined with most, if not all the other peculiarities that can be desired. That period is, I fear, still at a great distance.

But, if these remarks shall tend in any degree to call the public attention to this subject, whether with a desire to refute or to confirm these remarks, it will equally answer the end in view, which is to remove hurtful prejudices, and to discover the truth. He who does so, is on my side, alike if he refutes by just reasoning, from well-established facts, as if he confirms these remarks.

*The SECRETARY of the Bath and West of England Society, to Dr. ANDERSON.*

THE Secretary of the Bath and West of England Society, begs leave, in the most respectful manner, to convey to Dr. ANDERSON, some few remarks and queries, which arose in the Committee, respecting his excellent paper on Wool-bearing Animals. In general, as might be fairly expected, this paper was much approved; but doubts arising on two or three sentences, they will be set done in order, and the Doctor will greatly oblige, by giving them a reconsideration and reply, as early as shall be convenient to him.

1<sup>st</sup>, “ And is it not also a fact, that  
 “ though it be now *proved to demonstra-*  
 “ *tion*, by repeated experiments, that the  
 “ wool of sheep brought from Spain *does*  
 “ *not degenerate in Britain\**, there has  
 “ been till this hour, *no attempt made to*  
 “ *obtain a single individual of the finest breed*  
 “ *of sheep* § *from Spain?*

- \* Query

\* Query from the Committee. *On what experiment or experiments is this fact, if it be one, founded?*

§ From the same. *Has not the attempt been made by the king, and succeeded? Or, at any rate, are not the rams selected and sent to him by the Marchioness Del Campo, to be considered as the best?*

2dly, “ Nor is there a single fact, that  
“ ever has been discovered, which gives  
“ the smallest countenance to the gene-  
“ rally received opinion, that heat tends  
“ either to make the fleece thinner in  
“ pile, or to encourage the growth of  
“ hairs among it. Far less that it ope-  
“ rates, as M. BUFFON and his followers  
“ assert, in producing permanent changes  
“ on the descendants of animals †.”

† Query from the Committee. *Is this a clear case? Do not our sheep sent to and kept at the West-Indies, rather prove the contrary?*

To JAMES ANDERSON, Esq. LL.D. F.R.S.

ANSWER

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ANSWER *to the* SECRETARY.

DEAR SIR, *Saturday, Feb. 25th, 1795.*

I THANK you for your very kind letter of the 13th instant, which only came to hand on Thursday last; I embrace the first post for acknowledging that favour, and of giving answers to the queries your Committee have done me the honour to propose.

1<sup>st</sup>, A variety of experiments have been made with the Spanish breed of sheep, for three years past, by many of the members of the Society of British Wool. I have seen many specimens of the wool of both parents, and of the progeny, which have been compared together, by the members of the Committee and others; and in no instance, has it ever been observed, that the wool of the progeny, where the breed was pure, was *coarser* than the average of the parents. Of the effects of crossing, and  
other

other peculiarities, affecting the wool in particular cases, I have not time to speak; I shall only observe, that, in general, the Spanish sheep that have come to Scotland have not been found to thrive, being liable to many diseases, especially the foot-rot. You are aware that bad health affects the *quality* of the wool, in a very remarkable degree, in some cases.

2dly, The king has certainly got sheep from Spain, as has the Society for British wool. But do the gentlemen of the Committee believe, that Mr. BAKEWELL, or any other eminent breeder, would have thought he could have obtained the very best kinds of British beasts, by getting the Dukes of \* \* \* \* \*, or any other Dukes or Duke in the kingdom, to order her or his steward to buy the best, and send them to him? Such are not the steps required to make improvements of this kind. Do we not all know, that every person of high rank is liable to be imposed upon by their servants and dependants, in almost every thing? And what would have been the consequence, if the steward had

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had wished to frustrate the liberal intentions of his mistress? No precautions have been adopted to guard against this. We know, that the *finest* woolled Spanish sheep have not been sent, because finer Spanish wool can be bought than any of them carried. And I have very great reason to believe, from the information of persons who have seen the flocks in Spain, that there are fine woolled sheep in Spain, much superior *in carcase* to any we have got \*.

3dly, If any of the gentlemen of the Committee knows of any well-authenticated fact, which proves that the fleece degenerates, as specified, in the West-Indies, I shall be glad to be informed of it. I know of none, though I know it has been asserted ten thousand times, by persons who never had adverted to the fact; before I did advert to it, I myself believed it firmly; since I investigated the case with attention, I have

\* For the precautions necessary to be observed in selecting sheep of the best sort, see Account of Russian sheep, Appendix fifth.



been obliged to abandon that opinion \*.  
When the gentlemen of the Committee ad-  
vert

\* It is very easy to account for the origin of this popular opinion. Wool is not an object of attention to any person in the West Indies; it cannot be there manufactured, and there are no uses to which they can apply it in its unmanufactured state, of course, the fleece of the sheep is entirely neglected, and in that state the wool of European sheep when carried thither will not be shorn, but will be suffered to loosen from the skin, and drop off of itself, the consequence of which will be, that if there were any kemps among the wool, which is very often the case, these hairs will remain fixed in the skin while the wool falls off; in which state the animal is perfectly bare of wool, and in its stead, the body is seen to be covered with a thin coat of long coarse straggling hairs only.—This fact being several times observed, is more than sufficient to give rise to an opinion, that all sheep which come from this country, have the wool transformed into hair, and this will naturally be ascribed to the influence of the climate, though nothing can be more certain than that the same phenomenon would take place in Britain. In fact, it does take place every year in Shetland, where the practice of sheering their sheep does not prevail. So much for the individual sheep, that have been sent out from this country.

With regard to the descendants of these sheep, as the few sheep that go from this country are suffered to run at large among the native sheep, they are of course will intercopulate with them, so that the progeny will be a mongrel

vert to the numberless opinions that are readily admitted, without proof, as facts respecting wool and sheep in Britain, they will not be surpris'd at this opinion respecting sheep in the West-Indies, being admitted. I have been in the custom, for many years past, of admitting no assertion, on subjects of this sort, without proofs; and in searching for proofs on this head, I have found a great number of facts, that have oblig'd me to abandon my former opinion. No opinion is more universal in the West-Indies, than that the sheep which are deemed the native breed of the island of Jamaica, carry *no* wool at all, but hair only. I had an opportunity, I think, of sending to you a specimen of the natural fleece of one of those sheep, which consists, for the greatest part, of wool, perhaps *finer* (un-

grel race, approaching to the nature of the native sheep.—These being once more cross'd, will approach nearer to their nature, and so on, till, in a short time, they will be in no respect distinguishable from the native sheep.—Here, then, is a pure metamorphosis of the kind—but it is a change which has no dependance on climate.—The same thing must have happened, under similar circumstances, in Siberia or Lapland, just as much as in Jamaica.

doubtedly

doubtedly softer) than the best Spanish wool.

Please to accept of these hasty notices in good part, and believe me to be, with great sincerity,

Dear Sir,

Your obliged humble servant,

JAMES ANDERSON.

*Mr. Wm. Matthews.*

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ADDITIONS.

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ADDITIONS

*Made to the above, in the year 1797.*

SINCE the paper above was written, two valuable animals of the wool-bearing class have come to my knowledge, with which I was then entirely unacquainted—one of these is the Jamaica breed of sheep, concerning which, I have mentioned the nature of its hair at page 240, in putting this edition to the press. The sheep itself was discovered in Britain, by Sir Joseph Banks, Bart. who favoured me with the following account, in a letter, dated Nov. 1794. Sir Joseph had occasion to visit an acquaintance, immediately on that gentleman's return from Jamaica, and in walking upon the lawn, before dinner, he saw a sheep of a very unusual appearance.—He asked what sort of a sheep it was, and was told it was one of the native Jamaica sheep, which had been put on board for live stock, but having had a quick passage, its life had been saved. Sir Joseph, who had honoured me with some communications respecting wool  
just

just before that, expressed a desire to see its wool. Wool! said the gentleman, it carries no wool, but only hair.—Well, said Sir Joseph, let me see the nature of its fleece, whatever it be.—On that the gentleman called the sheep, which, being quite tame, came up to him.—He then plucked a lock between his finger and thumb from the back of the sheep, and looking at it for some time, he exclaimed, with some degree of astonishment—here is actually some wool, and until this moment I never did believe that these sheep carried the smallest portion of wool whatever, though I have seen great numbers of them daily for many years past! Sir Joseph examined it also, and sent the lock, exactly as it was pulled, knowing I should deem it a great curiosity. The lock consisted of hair of the kind above described, and of more than an equal quantity of wool of a singularly fine quality; being much finer than any Spanish wool I ever saw, and as soft as silk.—At that time it was about an inch long, and by the usual shearing time, I suppose it might have attained nearly to two inches in length; and

and as the hair could be easily separated from the wool, seeing it is uniformly about half an inch longer, I have no doubt but the fleece of this animal would be of as great value as the best fleeces that have been ever reared in this island ; as the wool appeared to me to be equally soft with Vigonia wool, which frequently sells here, when clean picked, at the rate of one guinea per pound,—and it has the advantage over that, in being of a pure white ; so that it admits of being dyed of any colour. I consider this breed of sheep, therefore, as a very proper object for experiment.

It has been, in general, believed, that the breed of sheep just now described, which are found in Jamaica, are the very same sort with those in England, which have degenerated from their original state, in consequence of the influence of the climate, which is said to convert the English wool into hair,—and it has been often seriously affirmed to me, by respectable persons, that there could be no doubt of the fact, that English sheep are invariably transformed into that kind of animal after being a few months in Jamaica. I had been, however,

ever,

## WOOL-BEARING ANIMALS. 285

ever, assured by Dr. Wright, who was an attentive naturalist, and had lived many years in Jamaica, that they were a distinct breed.—But had I never heard any surmise of that sort, nor been able to account for the prevalence of that opinion in any way, the fact above stated puts the matter beyond a doubt.—No sheep that are reared in this island, ever carried a hair of the kind which is natural to that sheep; nor have we any wool that can admit of being compared with it, in point of fineness. We have never, in short, seen any wool of the same sort in this island; and that breed of sheep seems to be more nearly allied to the Argali of Pallas, than to any other breed of sheep hitherto described. None of the breeds of sheep reared in this island, approach to it in the smallest degree. It is curious to observe that the *hair* of this animal is much coarser, and its *wool* much finer, than can be found on any of the sheep reared in Britain; so that, by the vulgar hypothesis, it would seem that the climate produced two effects on the same animal at the same time, directly the reverse of each other!

The

## 286 DISQUISITIONS ON

The other valuable wool-bearing animal of which I have received notice, is what has been conjectured by Dr. Anderson, of Madras, with much seeming probability, to have been the animal which gave rise to the famous Argonautic expedition, as the wool of it may, in the strictest propriety, be denominated the GOLDEN FLEECE. Hitherto it has been, in general, supposed that the epithet *golden* was applied to the fleece of Colchis, merely allegorically, in allusion to its value; but, from the specimen sent to me, it may be literally and truly called such; for I never saw any natural animal production, which so nearly assumed the appearance of gold as that does. A bit of the skin, about the size of the palm of the hand, with the wool adhering to it, was brought to Dr. Anderson, by a Sepoy, who had been employed in a military expedition to the northern parts of India, and all the account he could give of it was, that it was part of the pillage that had been obtained after the overthrow of one of the chiefs in those regions. A part of this Dr. Anderson sent to me, and it is now in  
my



my possession. The pile is soft and fine ; its colour is a bright yellow, of the colour of gold, and it has a gloss lustrous as silk. In length, it is about nine inches ; nor is it frizzed up, like most kinds of wool, but hangs down with a gentle wave, tending to a kind of spiral curl upon it, very much resembling the wool of the Angora goat in every respect, except the colour. It is evidently not dyed,—for not only is the bit of skin to which the wool adheres of its native colour, but there is plainly perceptible, a small variation in the tint, between the roots and the points of the wool, the roots being rather the lighter of the two, which would not have been the case, if it had been dyed. In short, the beauty of this lock is such as to have attracted, in a very high degree, the admiration of all who have seen it ;—and even in the present state of arts, a manufacturer gave it as his opinion, that it was an article of so great value, that he would purchase it, if it could be procured, at an exceedingly high price :—

backward to those distant  
silk was not at all known

It if we look  
periods when  
Europe, and  
when

when the art of dying was but in its infancy, we can easily conceive, that the value of an article of this kind would be deemed inestimable.

We have to regret that so little is known of the animal which produces this fine fleece.—All that is as yet done, is, to ascertain that such an animal does actually exist; and that, of course, it is not beyond the bounds of *possibility* to discover it. In that enquiry, Dr. Anderson, at Madras, is engaged at present, and no man, from the great range of his correspondence, the universality of his acquaintance, and the respectability of his character in India, is so likely to succeed in the discovery of it as himself: Nor is any one so likely to procure the living animal, if it should be discovered. But such animals, if obtained, ought not to be delivered up as toys to princes, or their dependants, to play with.

Since the fact is now undeniably established, that there are various *breeds* of the same species of animals, which differ radically from each other, and preserve these distinct characteristics under every change of climate or management, while the  
blood.

blood continues uncontaminated ; and since we find that these variations respecting the fleece, or external coat of hair, are so very great as has been above made evident, we have reason to believe, that the variations which may take place between different breeds of the same species of animal, respecting their other qualities may be equally great and striking as those which regard the fleece ; it therefore behoves us to advert to all the peculiarities of every different breed or variety of animals, with much more care than we ever yet have been accustomed to do, if we wish to carry our improvements to the highest degree of possible perfection. This opens up a tract for enquiry, that is as yet entirely unexplored ; for, so long as an idea prevailed that the different varieties of the same species of animals were merely casual deviations from the same parent stock, these accidental variations must have been considered as of a nature so fleeting and perishable, as not to be worth the pain of accurate investigation.

In consequence of this mode of reasoning, the real qualities of the different kinds

kinds of wool and hair, produced by different breeds of sheep, have scarcely been at all adverted to, because, where a variation was perceived, it was attributed to climate, food, &c.—and not to the nature of the breed.—Hence it was inferred, that under the same temperature, and with the same food long enough continued, all the varieties would be nearly the same. By a similar mode of reasoning, we have acquired the habit of thinking the other qualities of all the varieties of any one class of animals are actually the same; and that if they appear at times to differ, this is owing to the operation of accidental circumstances only: of course, we have been equally careless in observing the other qualities as that of the wool, so that many of these peculiarities have totally escaped our notice.—I shall beg leave here to give some hints respecting these, merely to forward this species of investigation:

The *size* of animals, like the qualities of the wool, have been supposed accidental—That this is not the case, admits of clear proof. None of the creatures we rear, are so much under our management, or so  
 universally

universally subjected to our observation, as the dog; nor are there a greater diversity of breeds to be found in any species of creature.—In respect of size, in particular, this is very remarkable, for the smallest lap dog, when compared with the largest sized mastiff, is not, perhaps, one twentieth part of its bulk. And that this is not owing to the fullness of feeding, is very evident, seeing that these small dogs are in general much better fed, and more highly pampered than those of the largest size. Hence we are led to conclude, that there are varieties of the same species which are radically different in point of *size*, and which cannot be made to approach to each other, by any mode of management whatever, where the blood is unmixed.

The same thing is observable in other animals. The breed of cattle peculiar to the highlands of Scotland, may be made as fat as the Holderness breed; the Shetland breed of horses as the large black dray-horses in England, and the Chinese hog as the Berkshire pig; but no management can bring these small *breeds* to equal the

the others, in point of size, when equally well fed. Observe, I do not say, that full feeding will not raise the size; for it is an undoubted fact, that every animal when well fed, will rise to a larger size than where it is not well fed; but this rule applies equally to all animals, to the larger as well as the smaller, so that if equally well or ill fed, they will still preserve their distinctive size.

Different breeds of the same species vary from each other also in respect to shape. The pug-dog, the spaniel, the greyhound, the mastiff, are all distinguishable from each other in point of shape, by the slightest glance of the eye; nor can any management tend to confound them, if the breeds are preserved unadulterated. So is the Devonshire, the Lancashire, the Holderness, the Kiloe cattle; the Shetland, the Lanarkshire, the Suffolk, the Leicestershire sheep; the Swedish, the Holstein, the Spanish, the Arabian horses; each of which can be recognised by a glance of the eye, when compared with the others; and they are all equally permanent.

Different

Different breeds vary from each other also, to an astonishing degree, in respect to their propensity to increase in corpulency by abundant feeding. No art can ever bring the grey-hound to be as full of flesh as a breed of lap-dogs (I believe they are called shock-dogs) which have a propensity to fatten more than any others ;—and, it is not a little remarkable, that some of the leanest kind of dogs, eat the most food of any, in proportion to their size. It has been often remarked, that a grey-hound is the most voracious of all dogs, and that a mastiff, in proportion to its size, eats very little, though it may very easily be fattened. The blood-horse and the alderney-cow, can never be made so fat as many other varieties of their species.

These observations lead to very important conclusions, to the farmer ; for if such remarkable diversities be occasioned merely by the *breed*, it behoves him to be exceedingly attentive to this article, and to investigate, with the most careful impartiality, the peculiarities which essentially discriminate one breed from another ; to

consider each peculiarity of every breed, individually and separately, and not to blend them in the gross, as has hitherto been done. It would lead me much farther than I at present choose to go, were I to enter minutely into this subject—my object is not at present to teach others, but merely to put them into a train of instructing themselves; and, with that view, I shall merely glance at a few other circumstances, before I put an end to this Essay.

It is not the abundance of food, that will produce a large breed of animals in any place, though the want of food will every where stint them in size. Hence we are not to conclude, that wherever a small breed of any domestic animal prevails, it must be a poor barren country.—If the animals be fat, it is a proof they have abundance of food, whatever be their size—though if they be thin, it is not a proof that they are in want of food. The Shetland poney is of a size as small as that of the island of Tiree; but the first is a plump strong-made animal, that is almost continually fat, the last is a thin  
puny



puny creature, that looks always starved, though its native food is richer. In like manner, the Alderney-cow is a hard-boned, hungry, starved-like creature, when even on the best of grass. The Kiloe is not much higher in stature, but it is a burly looking creature, compared with the other, and has a tendency to fatten kindly wherever it has food enough. The first is a native of a fine climate and good soil; the last is found in an ungenial region, and very unfertile country.

From these considerations, it will appear, that several of the questions which have been keenly agitated among warm disputants, for many years past, do not admit of a solution in the way they have contended for. One party, for example, maintains that it is more advantageous to rear large than small beasts; and, in confirmation, he produces a fact, by which it appears, that in that particular case, the large beasts were, in truth, the most profitable of the two. Another, on the contrary, maintains, that small beasts are universally more profitable than large, and states a fact, which proves clearly, that

the small breed was indeed more beneficial than the large. They may be both right as to the particular facts alleged, and both wrong as to the general conclusion. It is not the size, but the other peculiarities of the individual breeds that influence this question; seeing two breeds, of equal size, may possess properties extremely dissimilar. It is, therefore, a groundless prejudice, either to approve or to condemn a particular breed, from adverting to its size only; of course, we ought to reject none from the particular investigation of its qualities, above recommended. For this reason, the Musk ox, of Hudson's Bay, which is rather small; the Bison of Louisiana, which is of a larger size, and strong, both of which fatten kindly; the Alderney-cow, which is also small, but valuable on account of its milk; and the Arnee, of Hindostan, which is by far the largest of the cattle-tribe yet known, should each of them have their respective peculiarities distinctly ascertained.

Of all the animals of the *Bos* tribe, the Arnee is, doubtless, the largest yet known;

known; and although largeness of size be not in itself a quality that ought to recommend an animal to favour; especially where it is to be suffered to graze upon the meadows, where the exorbitant weight of the creature may be sometimes hurtful; yet, there may arise occasions, in which great bodily strength may be of singular utility: and as it is possible to feed beasts always in the house, should the animal be in other respects desirable, the damage that might be done by its weight in pasturing, may be thus entirely avoided. This creature, when tamed, is gentle, and very susceptible of being trained to any purpose that may be wanted; but, with its other qualities, we are very little acquainted. It is known in the higher parts of India, where it is used as a beast of parade, nearly in the same manner as the Elephant, to which, in point of size, it more nearly approaches, than, perhaps, any other animal, that is yet known to us, as I chanced accidentally, to gather from the following incident:

Mr. William Haig, while first lieutenant on board the *Hawkesbery* East Indian,

diaman, then in the river of Ganges, about fifty miles below Calcutta, observed an animal in the river, alive, but floating towards the sea, carried down by the current; a boat was immediately put off, and the creature secured by means of a rope thrown over its horns, and towed towards the ship. They were surprized at the largeness of the size of the animal; and being just come into the river, from Europe, it was accounted a glorious prize, and instantly slaughtered, for the sake of fresh provisions. It was found to be a bullock of only two years old, yet when cut up, the four quarters weighed full 1450 pounds. From this datum we cannot suppose, that a beast of this kind, of full stature, and completely fatted, would weigh less than 4500 pounds; for we know that a lean bullock, of two years old, will not amount to one-third part of the weight that the same animal would have attained at nine years of age, when fully fatted; and as this creature must, in all probability, have been carried down the river for, perhaps, a thousand miles, before it was caught (none of these cattle, that

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## WOOL-BEARING ANIMALS. 299

I have heard of, being bred lower than Plassy) we must suppose that it would be very much emaciated; yet all on board the ship thought it excellent eating. As the head, feet, skin, entrails, and tallow, of a fatted animal, weigh very little less than the four quarters, we shall see reason to believe that some of these, when alive, may be found, which will not be less than from 80 to 90 cwt. upwards of four ton weight! so that it must be a very stately creature. They are said to be sometimes eleven or twelve feet in height.

The horns of this breed of cattle grow right upwards, nearly in the same plane with the face. At first they spread outward, but as the creature grows older, they gradually bend inward, till at last they form nearly a circle, of a large size. I saw an Indian painting, in the possession of Gilbert Innes, esq. of Stow, in Edinburgh, representing a fight between an elephant and two tigers; a kind of entertainment, sometimes given by the grandees of India, for the amusement of the public. In this painting many people were present; some elephants were there also, under the care of attendants, and

three of these cattle were there seen also standing quietly, under the charge of their keepers, who were mounted upon them, nearly as the cornac is upon an elephant; nor were they represented as much, if at all, inferior in size to that monstrous animal.—The colour was uniformly black, except a tuft of red, or rather flame-coloured hair, pretty long, on the top of the forehead, exactly between the horns. It was guided by a rein fastened to the gristle between the nostrils. It is therefore plainly a domesticated animal, and its appearance is of the most gentle and inoffensive kind.

The Bison, or, as it is commonly called, the Buffaloe of Louisiana, is also a beast of a large size, and great bodily strength, and has a propensity to fatten kindly. It was not known that it could be very easily domesticated till of late; but I find, among other peculiarities respecting this creature, mentioned in the Seventh Volume of the Bath Society papers, written by a Mr. Turnbull, a very singular and easy method of catching them, which appears to be well known to the inhabitants of the back settlements

## WOOL-BEARING ANIMALS. 301

tlements in America, who often go out to hunt the Buffalo. He states, that if a female who has a sucking calf at her foot, chances to be killed, the calf never leaves its dam, even when the hunter comes up, but stands quietly by, and follows the body of its mother wherever it is carried, were it even into the heart of a city ; and as the calf is easily tamed when once got into hand, it seems to be often reared, in the back settlements, as a domestic animal. The writer of that paper does not there specify any of its other qualities, but its strength alone, which, he says, is much greater than that of the European ox, and its step longer, on which account he strongly recommends it as a beast of draught.

The *Zebu* breed of cattle has been also imported into this country, I find, from India, by several gentlemen, and is found to thrive here, and to breed perfectly well, so that it is probable, its qualities will come in time to be accurately ascertained. In regard to one particular, both these breeds possess a peculiarity, that is well known to be totally distinct from any of the breeds of cattle that are natives of this country. The  
peculiarity

peculiarity which distinguishes the Bison from other varieties of the *Bos* tribe, is a large hump upon the shoulder, which when cut up, is found to afford a flesh that is of a quality totally distinct from that of any other part of the body, and is universally esteemed much more delicate eating. The *Zebu* is also distinguished from other creatures of the same genus, by a particular kind of excrescence, that rises from the shoulder also, but in a manner totally different from that of the Bison; and the quality of the flesh of this excrescence (which is of a considerable size) is different from any meat furnished by our cattle, and differs also from that of the Bison. This is deemed such a peculiar delicacy, that I have often heard gentlemen who have been used to it in India, say, they found all the meat in this country, harsh to their palate, so that they could with difficulty bring themselves to eat of it. It is not impossible but the meat in the other parts of the body may also differ considerably from our's, and from each other. The skin also of these animals may be found, upon trial, to be possessed of properties that may render it highly valuable



## WOOL-BEARING ANIMALS. 303

luable in manufactures ; particularly that of the *Arnee*, which is probably, in many respects, different from that of the smaller animals of the same genus. It is certain, that the Indians make of the skin of the Bison, manufactured in their manner, a kind of leather, that is soft, tough, and very light, of which they form a kind of jerkin, or a shield, perfectly capable of resisting the force of an arrow. Whether this quality depends upon the nature of the skin, or on the mode of manufacturing it, remains to be ascertained.

I shall just add one other hint respecting *varieties* of animals of the same species, with a view to lead to an investigation, that never has yet, that I know of, been the subject of elucidation. We have seen above, that different *varieties* of the same species possess certain permanent and distinct peculiarities, that cannot be altered but by an intermixture of blood. Those peculiarities that I have taken notice of above, respect chiefly external circumstances, which are very obvious to the senses.— There are other peculiarities, however, of a more obscure nature, if I may be allowed to

to adopt that expression, which, though equally useful, are not so easily ascertained by sensible marks which admit of accurate comparative trial, but which are still easily recognised, when you take two breeds that differ very much from each other.—Of this nature, is what is called hardiness, or persevering firmness under fatigue, often called *spirit*—as contrasted to that sluggish want of mental and muscular exertion, which is called *softness* in horses; the blood-horse, for example, and some other noted breeds of active horses, compared with the large black dray-horse. Of a nature equally obscure, though, I am satisfied too, equally distinct from each other, is the taste and flavour of the flesh of different breeds of the same kind of animal, though this circumstance does not seem as yet ever to have attracted the public attention in the smallest degree. Every person knows, however, that there is an exceedingly great difference between the delicacy of the meat he eats at different times; but as it is well known that the flavour of meat may be affected by circumstances that are totally unconnected with the breed, such as, in  
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some kind of animals, the age at which they have been killed, or the nature of the food upon which they have been fed, or the time the meat has been kept after it has been slaughtered ; and as no pains is, in general, taken to discriminate how far either of these circumstances have tended to operate in the particular case in question, each individual feels himself, in general, disposed hastily to conclude, that the particular circumstance which he chances to have fixed upon as obnoxious, or the reverse, has occasioned the good or the bad flavour he perceives. Is his mutton peculiarly delicate—one man immediately concludes, it must have been fed upon heath, which gives it the high flavour.—If bad, it has been fed upon turnips ; or it is, perhaps, the age—or the size—or any other circumstance that may chance to operate upon his imagination at the time—but he seldom thinks of ascertaining with the necessary degree of precision, whether this be the fact or not. I myself know, for a certainty, that I have heard things of this nature repeatedly mentioned as facts that were incontestible, which I knew at the time to be totally different

ferent from what was asserted, when it would have been very idle, or very rude in me to have contested it:—neither have I myself had opportunities of ascertaining the fact referrible to this head with the necessary precision to be able to lay down any rules that can be relied upon. My observations go no farther than to furnish me with reasons for doubting; but they have been long enough continued to authorize me to suggest hints for farther investigation. In short, I have seen reason to be satisfied that, independant of age, and food, and every other circumstance which tends to affect the taste of meat, there is a flavour peculiar to the meat of every distinct breed of domestic animals that are reared in this island, which can only be changed by blood. I do not say that this flavour cannot be altered by the circumstances above stated;—far from it—for I know that the alteration that may be produced by these means is always very great. What I mean is simply this; that under the same circumstances respecting age, food, and every other particular, the flavour of the meat of two distinct breeds will be different, in most cases.

In regard to mutton, I shall beg leave to specify the true Welsh breed, and the new Leicestershire, as the greatest contrast to each other that I know.—The first I conceive to be by much the finest flavoured mutton I have seen, and the last the lowest.—The difference is to me nearly as great as between a golden pippin, and an ordinary apple. Whether this difference of flavour depends upon the breed or the feed, may be ascertained by very easy experiment. Let any gentleman who has a convenient inclosure, buy a score of lambs of one year old, of each kind; let them be turned together into as rich a pasture as you please, and let the two best of each kind be always chosen at the same time, when wanted, and then slaughtered, and treated in every respect alike, till the whole shall be consumed, as they advance in years. Two of the same age will thus always be compared together; if no difference in the flavour be then perceived, I am clearly in a mistake.—Many other good consequences, besides that here stated, would result from this experiment, if conducted  
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with accuracy, and faithfully recorded ; and it would cost nothing.

I shall just add, that I have reason to suspect that the delicacy of flavour is by no means necessarily connected with the *size* of the breed ; for though, in this instance, it should be found that the smallest is preferable, I have no doubt but that in other trials it would be found that the reverse would be the case.

FINIS.

JAN 19 1920

